What To Do

A Practical Handbook for Motorists

By

W. D. C. Moore

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What To Do

---To Keep Down Motoring Expenses

---To Avoid or Remedy Motoring Troubles.

A Practical Handbook For Motorists

By

W. D. C. Moore

With Chapters on Various Essential Parts and Functions Contributed by Well Known Authorities

The Motor Book Company, Inc.

Benton Harbor, Michigan

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Dedication

You remember him—that Chap you found, ten miles from anywhere, standing by the side of a "dead" automobile.

He had tried the starter a hundred times or less, repeatedly turned the lights on and off, looked at all his spark plugs and even kicked the tires but the darn thing simply would not go!

And then, you came along, found that his timer wire had grounded, fixed it and he thought you a wizard, no less.

Let's dedicate this book to him with the hope that it may save him, and others like him, many hours of aimless puttering by showing them WHAT TO DO.

Introductory

Would you become the Master as well as the Owner of your car—able to drive it efficiently and economically when "she's running fine"—able to fix it, or least to know what is wrong, when it develops the ailments to which an automobile is commonly subject? If so, this book is for you.

It will make no effort to teach you automobile repairing in any broad or technical sense. It will not tell you how to rebore cylinders, grind valves, replace piston rings or how to repair or replace any broken or worn out essential part. Such work lies almost wholly within the field of the automobile repair man and usually calls for special mechanical knowledge, special tools and shop equipment. You will be well advised to leave it to a competent repair man whose experience and equipment assuredly qualify him to make such repairs more efficiently than any mechanically inclined amateur, however gifted.

And, even if you have the knack, the ambition and the ability to do real surgical work on your car, your talents in that direction will be needed but seldom. Probably ninety per cent of automobile troubles yield to what may be called "simple home remedies."

Those mysterious and often terrifying knocks, the poundings, rattles and wheezes, failure to start, going "dead" on the road, the missing, the overheating—all the long, long list of automobile troubles, barring only those caused by broken or worn out parts,—none of them need chill you with dark forebodings of a car out of commission and a probable repair bill. You yourself, can nearly always end them with a "simple home remedy" and without a great amount of work or an-

noyance if you have ordinary mechanical ability and if you are not afraid to sometimes soil your hands.

First, you will want to know what the trouble is and, next, what to do. It is the purpose of this book to help you find an answer to both questions. It may not cover every trouble which CAN happen but you can depend on it to cover the troubles which you will most commonly encounter and when you are able to cope with all the ordinary troubles, you will be able to go the balance of the route unaided.

You will be Master of the car you own.

W. D. C. M.

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CHAPTER I

YOU MUST KNOW WHAT MAKES IT GO

Just as the small boy said, in his composition on pins, that "Pins have saved lots of lives by people not swallering of them," it may also be said, of the troubles, annoyances and inordinate expenses frequently incident to running an automobile, that most of them can be cured by being prevented.

It all depends on the degree to which the owner is interested in his car. No matter whether his interest arises from a prideful desire to drive a good-looking, sweet-running car that can always be depended upon to carry him swiftly and smoothly any time and anywhere the roads go or whether he values his car mainly for its utility and is interested almost wholly in its ability to run and keep on running without bother and at minimum expense. No matter why he is interested in his car, if he is really interested in it, he will find it no great trouble to use an "ounce of prevention" which will enable him to escape ninety per cent of all the motoring troubles he has ever experienced or heard of and, incidentally, to save the cost of the "pound of cure" which otherwise must be paid for in time, trouble or in hard cash to the repair or supply man.

This "ounce of prevention" contains no elements of magic or of mystery. It calls for nothing more than the appreciation of a basic fact (to which most drivers

pay little heed) namely, that notwithstanding its marvelous efficiency, an automobile is only a machine which, like any other machine, must be operated properly and cared for correctly if it is to run with greatest efficiency, fewest repairs and adjustments and at the minimum expense.

To the credit of American automobile manufacturers, it can be said that nearly every standard car on the market is well and honestly built—built to run on and on, indefinitely, and give all that its owner can ask for in reliable and economical service. How long and how well it will run and what it will cost to run it, depends more on the driver than on the manufacturer.

Not infrequently one sees or hears about some car that is still running after years and years of satisfactory service. Of course such a record indicates that the car had lots of in-built stamina, but it indicates also—and more emphatically—that it must have been driven by a man who knew how to drive it and how to take care of it. Poor (careless and inconsiderate) drivers never hang up any economy, reliability or long-service records, no matter what make of car they drive.

A driver's license is not conclusive evidence of driving proficiency. The mere ability to drive a car—to steer and to work the various pedals and levers and switches—falls far short of being all that one must know and do in order to be a really successful motorist.

However skillful one may be at the steering wheel, his skill can not offset a lack of intimate knowledge of his car. The less he knows about it, the more it will cost him to run it, the more "trouble" he will have with it, the sooner he will want to sell it and the less he will

get for it because used cars, like old horses, reflect the nature of their previous service.

If the driver's knowledge of his car is restricted to the four S's—start, steer, slow down and stop—if he knows nothing about how the mechanism of his car works, "its wonders to perform," he will never be able to get from it all the service for pleasure or for profit which the manufacturer of the car has been at such great pains to build into it.

Realizing this, every car manufacturer furnishes with each car an "instruction book" which describes his car in fullest detail. The information a driver may obtain from some friend or from an instructor or whatever he may know about some other car of a different make will be of value but nothing can take the place of the first-hand information to be gleaned from the instruction book that comes with the car.

But because this book is not impressively bound or perhaps because the car-owner considers it as some sort of a catalog or a piece of literature intended to still further "sell" him on the merits of his car, it is too often thrown away or put away after a casual reading and the car owner remains without any real or definite knowledge regarding the mechanism of his car and the attention required by certain parts of it.

If you are a Novice, driving your first car, master your instruction book. If you've lost it, call on the dealer for another copy. Read it, study it; find out the function of each essential part; learn each part by name and location so that you can find it on your car. Be sure you learn which parts require attention and how often and which parts you should leave alone.

Above all—learn what points should be lubricated and how often and the kind of lubricant advised by the manufacturer.

If you are an Old Timer, don't be too confident in your knowledge. What you know about one make of car may not be all you need to know about a car of different make. If you are not absolutely familiar with the car you are driving this year, you had better study the instruction book that describes it. No matter how much you know, a "review" won't hurt you.

The manufacturer of a car knows more about it than anyone else. He is directly interested in helping the owner to operate it with satisfaction. He has published his instruction book in order to help the owner to an understanding of his car and its various working parts, how to drive it and how to care for it in order for it to serve with greatest efficiency and least expense.

It is the car owner who hasn't become thoroughly acquainted with his car—whether from his instruction book or any other authoritative source—who knows only that gas, oil and water, put in at proper places, "makes her go"—who has most "trouble" and is the most frequent visitor at the service station with complaints of something being wrong. His operating experience is nearly always expensive and if not actually unsatisfactory, he at least, fails to get from his car the sort of service the manufacturer intended him to get, and usually he blames the manufacturer for it.

The more intimately a driver knows his car—each part, the functions of each part and the attention each part requires—the less reason he will ever have to complain about the way it runs or what it costs to run it.

If he knows exactly "what makes it go," he can and will give it the attention it needs to keep it running sweetly and he can and will avoid any driving practice that is likely to cause undue strain, unnecessary wear or tend, in any way, to lower its efficiency.

There is no road to real driving efficiency that does not lead over the hill Knowledge. If you take a detour, you'll never get there and you'll miss most of the motoring pleasure you paid for when you bought your car.

CHAPTER II

ON PROPER DRIVING—

Some "Driving Suggestions"

"Good form" and "bad form" in driving is largely a matter of temperament. if one is constitutionally careless or negligent, one will naturally drive in a "slap dash" manner that will be hard, alike, on car and pocket-book.

But, on the other hand, if a Car-owner is interested in his car and really wants to operate it in the way it should be operated and his desire to do so has been strong enough to prompt him to seek and acquire an intimate knowledge of its mechanism, his driving experience will be generally trouble-free and comparatively inexpensive. Then, to be able to drive properly—without accident or, at any rate, without accidents caused by his own lack of skill or care—without undue strain or wear upon the motor, the transmission, the brakes, the batteries or other essential parts and without excessive expense for repairs, adjustments or supplies—he will need only driving experience.

While, in driving a car, just as in anything else, a man must get his own experience, he may be helped by the experience of others. It is to enable the interested car owner to thus supplement what he may learn from his own personal experience with hints gleaned from

the experience of others that the accompanying "Driving Suggestions" are given.

To the driver of long experience, many of these will appear elementary but among the number given, even he will hardly fail to find at least a few that should helpfully increase his motoring knowledge.

The simplest, easiest, and safest way for a beginner to become familiar with the various levers, pedals and switches is for him to jack up the rear wheels clear of the ground, letting the rear end rest on a box or other solid object that will hold it steady, and then get in, start the engine and practice with the spark, the accelerator, the clutch, the gear shift and the brake until he can handle each with perfect ease and certainty.

A beginner should not attempt to drive at all until he is absolutely confident in his ability to change gears easily, apply brakes properly and do both without any danger of becoming confused in an emergency.

No beginner, however confident in his ability to start, steer, slow down, stop, etc., should venture out on the road unaccompanied by an experienced driver until his knowledge has been confirmed by practice.

Before starting out see that the radiator is full, that there is plenty of gasoline in the tank and—without any guessing—that there is plenty of oil. Ask yourself when the grease cups were looked after and inspect any you may be doubtful about. See if the tires are sufficiently inflated. To save time by neglecting these details is to "save at the spigot and waste at the bung."

Before starting engine, see that gear lever is in Neutral; insert switch key as far as it will go and give proper turn; see that throttle is open but slightly and that spark is fully retarded; pull out choker; press down firmly on starter pedal or button.

The instant the engine starts, take the foot off the starter. Otherwise serious damage may result.

Never allow motor to run any length of time with the choker out. This gives an excessively rich mixture and consumes an abnormal amount of gasoline besides promoting the formation of carbon.

If the engine doesn't start after a fair trial with the starter, leave the starter alone and look for the trouble. Its no use

to wear out the batteries by making the starter turn the engine over uselessly.

To conserve starter current, it is good practice to hold clutch out while starter is cranking the engine.

After the engine starts, advance the spark. To run with spark retarded not only consumes an unnecessary amount of gasoline but also has a tendency to overheat the engine and causes rapid carzonization.

Running with the spark advanced tends to keep down heating and lessens gasoline consumption but if advanced too far the engine will pound or knock. Learn by experimenting the most advanced position practicable. When using low gear on hills or in sand or mud, the spark should be advanced further than when running in high gear at ordinary rate of speed on good roads. Generally speaking, the faster the engine (not necessarily the car) is running ,the further the spark should be advanced.

Do not race motor unnecessarily when starting, especially in cold weather. Allow motor to run slowly for a few minutes until the oil has had a chance to circulate. Oil congeals when cold, but thins rapidly after the motor is started. Racing the motor is injurious and is not needed at any time.

For the same reason, one should not drive fast until the motor has had time to warm up.

When starting car, be sure the gear lever is in Neutral before letting in clutch. Never attempt to start with car in gear. After engine is running well, move from Neutral into Low, press in clutch and as the car gains a little momentum, into Second and on into High which is the usual driving position. Never attempt to start in gear—even in Low.

When changing from a lower to a higher gear, be careful that the car is moving with good momentum. Otherwise, the engine will stall or "buck-jump" with consequent strain and racking. Always speed up a little before making gear change and be sure to remove foot from accelerator before pressing out clutch.

Be very sure to press out clutch before making any gear change or broken teeth will likely result.

The clutch pedal should be pressed out sharply and released slowly—always slowly—in order to permit it to take hold gradually.

To change from a higher speed to a lower, release clutch, speed up a little, move gear into Neutral and engage clutch an instant, press out clutch and move quickly from Neutral into next lower position, engage clutch, immediately opening the throttle or foot control. To move lever from Neutral directly

to lower gear position desired is easier but wears or burns the clutch facing.

Learn how to shift gears easily. Noisy, clashing gear changes indicate either ignorance or carelessness. Clashing the gears burrs the edges of the gear teeth. When they get in that condition, gear changes are hard to make and an early renewal of the gears will be necessary.

Many an accident occurs from unwillingness or hesitation in changing gears. A car in High is permitted to drift along and get into a tight place in traffic and a collision or other accident results. Better always change into a lower gear if there is any probability of it becoming necessary to do so.

Unless a driver wants to "show off," he will not climb hills on High. If he succeeds in doing so, he does it at the expense of his car and if he fails—if the engine stalls—he may roll backward and off the road before he can make the necessary gear change. He had better take a running start whenever possible and the moment the momentum is spent, shift into Second or even into Low if the engine begins to labor.

In going down a hill, shift into high, throw out the clutch and let the car coast, keeping it under control with the foot brake and the emergency brake, using each alternately, so as to prevent either from becoming too hot from continuous friction. If the hill is very steep, go into Second just before starting down, switch off the ignition and let the clutch in gradually. The engine will then act as a brake, but the brakes should also be used as suggested above.

On coming to a considerable stretch of road that is sandy, muddy, rough or otherwise bad, do not try to force your way through it on High. Better shift into Second at once and get the benefit of the extra power and lessened strain thus secured.

To reverse the car, bring it to a standstill, press out clutch, then shift into Neutral and then straight back into reverse and release clutch slowly. Never attempt to reverse while the car has the least forward motion.

The Novice must become so sure of the different gear positions that he can make any change desired instinctively and without looking, for instance what would be the result from going into Reverse in crowded traffic when it was desired to go into Low instead.

Keep the eyes looking the way the car is moving—front or back, when going backward, never try to judge where the rear end is going by watching the front end.

When approaching a short stretch of road covered by broken stone or filled with ruts, it is best to speed up before reaching the bad spot and then release the clutch and permit the car to coast over or through it. This saves the tires since there

is no power on the wheels and also relieves the motor and driving mechanism from the strain.

Learn the great variations in speed which may be obtained when in any gear position by proper manipulation of the spark and throttle. Whenever it becomes necessary to reduce the speed of the car considerably release the clutch and apply the brake.

Do not ever compel the engine to pull against the brake such as is the case when the foot brake is used to reduce speed while the clutch is engaged. If it is necessary to use the brake, first press in the clutch.

Learn how to apply the brakes so as to bring the car to a gradual stop. To approach the stopping point at speed and then jam the brakes on hard may help the driver to make a showy "wild west" stop, but he pays for it in strain on the car and great and unnecessary wear on brakes and tires.

If you must stop in a hurry, push down hard on both the clutch and foot brake pedal and at the same time pull back on the emergency brake lever.

On a slippery roadway, a greater braking effect can be obtained with less danger from skidding, by pressing the clutch out and throwing the foot brake on and off. That is, holding the brake down an instant, releasing it and then pressing it down again.

Two things to remember about the emergency brake; always put it on when the car has come to a stop; always release it before the car is put in motion. The latter is something which some drivers consistently forget to do with results that can be easily imagined.

Be sure that the brakes are adjusted evenly. That is, that they "take hold" with equal tightness on each rear wheel. If they don't, the least harm that can ensue will be the premature wearing out of the tire on the wheel with the tighter brake.

It is good practice, on stopping and before you have killed the engine to open the throttle and speed up engine with clutch out. This leaves a charge in the cylinder and makes starting easier.

Any driver who wishes to do so can attract a lot of attention by taking corners on two wheels, but "he who dances must pay the fiddler." No car is built to stand such foolishness.

Slow down before turning corners not only for the sake of greater safety to yourself and others, but for the sake of your car and particularly of your tires, as well. It is said that rounding one corner at twenty-five miles an hour does more damage to tires than twenty or twenty-five miles of straight driving.

Turning corners too rapidly, particularly on slippery streets, is one of the most fruitful causes of skidding, especially on the front wheels.

When the front wheels skid, the trouble can usually be stop-

ped easily by applying the brakes and shutting off the power, being careful not to apply the brakes too hard or the rear wheels may start skidding too.

When the rear wheels skid, do not yield to the natural inclination to turn the front wheels in the direction opposite to the way the car is skidding. Be cautions too, about applying the brakes. Cut off nearly all the power and turn the wheels in the same direction the car is skidding. If there is danger of going into a ditch or curb or colliding, apply the brakes gently.

Chances of skidding may be minimized by the use of non-skid chains. On muddy roads they are well nigh indispensable and if one must drive on wet, icy or otherwise slippery pavements, they are almost equally necessary. Considering the damage which can be wrought by a skidding car, it is hardly too much to say that any motorisht can ill afford not to buy chains and to apply them at the first indication of their need.

Keep out of the car tracks and out of ruts as much as possible. To drive in these results in excessive wear on the thinner side walls of the tires. When you must drive in them, get out as soon as possible. In doing so, do not allow your front wheels to climb out along the edge. Make a sharp turn and jump out. Do not attempt to do this, however if you are going at any considerable speed or if you are driving in car tracks filled with water.

Learn, early, what happens when you turn the steering wheel. That is, how far the movement of the steering wheel will affect the movement of the front wheels.

A death like grip on the steering wheel indicates anxiety, nervousness and lack of confidence. Don't worry. Assume a natural, easy position. Take things as a matter of course. Everybody's doing it. You ca ndrive successfully if you know and use what you know. That death-like grip soon tires to the point of nervous exhaustion.

If it is ever necessary to change the direction of the front wheels while the car is not in motion, better do it by hand. To use the steering wheel for this purpose imposes a very great and entirely needless strain on the whole steering mechanism.

In going over bridges, sidewalks, tracks or other similar obstructions, it is better to strike them at an angle, thus throwing the strain on the springs successively and reducing the bounce and jar.

If it should ever be necessary or advisable to drive into a ditch, unless the ditch is very shallow, turn the wheels head on into the opposite bank. The front springs will then lodge into the dirt on the other side and keep the car from turning over.Furthermore, the car can more easily be pulled out afterward.

The dog you run over may have "its day" the day you run

over it. Better slow down, even at the risk of him biting off a front wheel, than run over him. His body may make you skid into some obstruction or into a ditch and it is even more likely that your steering mechanism will be damaged. The same caution also applies to pigs. They are dangerous even for locomotives.

If you want to announce to the world that you are a Novice or out for a spree with a rented car, blow your horn excessively. Keep it blowing. Otherwise, blow it only when you want to pass a car in front, when approaching a street intersection, or whenever, for safety's sake, you want to give warning of your approach.

It is not always appropriate to swear if the car approaching you at night has headlights so bright as to almost blind you. Maybe its driver is having just the same trouble on account of your lights. You might promote headlight courtesy and help abolish the glaring headlight nuisance if you would always remember to dim your lights when approaching another car or even a lowly farm wagon.

Avoid confusion and danger from the glaring headlights of an aproaching car by looking not at it but at the ditch on your side of the road and be guided by it until the car has passed.

If a single headlight is approaching it is not always safe to assume that it is on a motorcycle. Give it plenty of road space. It may be that one light is out on an approaching car and if the extinguished light is on your side, a collision might result.

Be very careful in passing another car which has slowed down or which is standing still on the road ahead of you. Slow down and blow your horn. Otherwise some one might step out in front of your car and an injury result.

"Look out for the cars" is advice that is just as good for the sophisticated motorist of today as it used to be for Farmer Corntossel. If the railroad is at the bottom or on top of a grade, better come into Second and look and listen before attempting to cross, rather than run the risk of killing your engine in front of an oncoming train by a too sudden application of power.

Don't race with a train for a crossing. Every day you hear of such races which resulted in a tie—and a funeral.

Before backing a car, be sure the road is clear, not only of other cars but of pedestrians, baby buggies and other vehicles and keep watching.

In passing another car going in the same direction, don't turn into the road ahead of it too quickly. It may be moving faster than you estimate and disaster may result.

Keep to the left when passing cars or other vehicles going in the same direction; to the right when passing cars moving toward you.

Pay frequent attention to the story your ammeter has to

tell. Should the pointer indicate "discharge" when the car is standing still with the lights off or if it does not indicate that the battery is charging when the car is running, drive right down to a competent Service Station and find out the trouble. Better not put this off even if it delays you to an appointment.

Never put cold water into a radiator while the motor is hot. Put your hand on the cylinder head; if you can not hold it there with comfort, wait until it cools before putting in water. Otherwise you run an excellent chance of cracking the cylinder.

Learn the song your car sings when it is running fine so that your ear will detect immediately any abnormal noise. The modern car, in perfect condition, is practically noiseless. If it develops a knock, a squeak, a rattle or click, it is trying to tell you that something is wrong and you had better see what it is before something worse befalls you.

Motoring courtesy is all too rare. The best way to encourage it in others is to practice it yourself. Don't drive in the middle of the road—"regardless." Keep to the right and when somebody wants to pass, get over further. On coming to a stretch of road with a good track only on one side, don't drive in and force another car to stop or climb out into the rough. The best road rule is the Golden Rule.

To drive without offense to the walking and driving public and without danger to them as well as to himself, the motorist must be considerate as well as skillful. Drivers of horse drawn vehicles, for instance, must be sometimes protected against themselves, if necessary. These may be driven by poor drivers who are not unlikely to become rattled and pull the wrong rein or the team may get frightened. The motorist must act the part of a "kind and elder brother" and drive in such a manner as will prevent accidents—even such accidents as might be caused by the carelessness or limited intelligence of others.

CHAPTER III

ACCIDENTS

The Cardinal Virtues of the successful motorist are really three in number. In addition to knowledge of his car, he must also have Common Sense and a Decent Regard for the Rights of Others. The lack or momentary disregard of the last two of these is always evidenced by carelessness which is the direct cause of nearly every automobile accident.

On the walls of a certain factory where thousands of men are employed, appear numerous placards which read "The Chance Taker is the Accident Maker." This terse statement contains so much of truth and is so particularly applicable to the operation of an automobile that it might well be memorized by every automobile driver. The observance of the warning it implies would do more than anything else to rid our daily papers of the stories of automobile accidents to which so much of their space is now devoted.

You see the locomotive engineer leaning out of his cab, his eyes fixed on the road, his hand on the throttle keeping his mechanism always under control, always watchful for any contingency which might necessitate a warning blast from his whistle, a slow down or a sudden stop. If he does this for no other reason, he does it because the rules laid down by his employers

require it and they require it because it is only by constant care and watchfulness that accidents can be avoided.

If such caution is necessary to the safe operation of a locomotive the course of which is fixed by a smooth track and which runs on a time and speed schedule which assures it the right of way, how much more caution should be observed in driving an automobile. Contrast the regular and usual operation of a locomotive with the harum-scarum, devil-may-care manner in which some automobiles are driven. Is it any wonder that the yearly damage to life and property due to automobile accidents is so much larger than similar losses due to railway wrecks or accidents?

Failure to sound a warning signal. Failure to give signal of intention to turn, back or stop. Failure to look and listen at railway crossing. Confusion in an emergency. Inability of brake to stop car when applied. Skidding. Disregard of Traffic Laws. Disregard of the rights of others. Speeding.

These, according to statistics, are the principal causes of automobile accidents. Analyze them one by one and in each you will find the trail of the Chance Taker.

And—to take chances—is this anything other than just another name for Carelessness? Can there be any other reason for failure to sound the horn when a warning signal is necessary?

If a driver, on turning a corner, on stopping or backing up, fails to give the proper manual signal, can he blame anyone but himself if a collision or other accident results?

Confusion in an emergency and the consequent doing

of the wrong thing can hardly result from anything other than a lack of knowledge or a lack of experience. Isn't it Taking Chances to attempt to operate a car under such conditions?

When the brakes are unable to stop the car, whether this be due to worn or oil soaked brake linings or whether it is because the car was going too fast, in either case, is it not due to plain carelessness in seeing that the brakes are kept in good condition?

"Put on your chains at the first drop of rain" warns the display line in an advertisement of a non-skid chain manufacturer. Isn't it Taking Chances to drive without chains on a slippery roadway?

There is a type of driver who feels that the modern traffic laws and likewise the ancient law embodied in the Golden Rule, tend to unreasonably abridge his rights as a free-born citizen, and he joys in his "smartness" when he successfully evades them.

He is the type who is highly amused at the antics of the startled pedestrian who barely escapes the wheels of his rushing juggernaut. At night, his presence is indicated by the blinding glare of his headlights and, by sticking always to the middle of the roadway, he compels recognition of his standing in the order of free and acknowledged road-hogs.

He is a Chance Taker of the most dangerous type. Naturally, he provides the direct or contributing cause for many an accident. If his "smartness" enables him, in this life, to escape the law and the punishment he so richly deserves, surely the motorists and others whom he has so often imperiled, may, without impiety, in-

dulge the hope and the belief that he will get what he deserves in the hereafter.

And—to complete the list of the sins committed by the Chance Taker, comes speeding; the cause of most of the automobile accidents as well as the source of countless minor strains and injuries which inevitably lessen the usefulness and shorten the life of the car.

The comic paragraphers have printed many jokes about the witless fool who "rocks the boat" but how much more newspaper space has been taken up by stories of automobile accidents due to reckless and even criminally careless speeding.

We are mildly interested when some hardy soul leaps from Brooklyn Bridge or shoots the rapids over Niagara Falls. So long as such exploits do not endanger others who value their lives more highly, we do not greatly care and we may even mildly applaud the "nerve" of the adventurer who attempts such feats.

No sensible person, however, can regard with complacence or can to any degree admire the skill or "nerve" of the driver who habitually takes corners "on two wheels," who speeds across traffic filled streets or who continually endeavors on city streets or country roads to emulate the speedway records of Oldfield or Milton.

If indulgence in a practice so dangerous is due to a lack of common sense or of decent regard for the rights and safety of others, it indicates a state of mind and the case is well-nigh hopeless. Traffic laws and traffic officers may impose some degree of helpful restraint but no real remedy exists short of penitentiary or the grave.

It is to be admitted that the temptation to speed may

sometimes be so strong that even the most sensible and careful driver may almost be pardoned for yielding to it. When the car is running fine and the road is smooth, "Danger has a smiling face." The driver feels that nothing will happen if he "lets her out a little"—and frequently nothing does happen any worse than the severe strain and rack to the car which is of course inevitable.

But, to yield to such temptation is to Take Chances. The greater the speed, the more likelihood there is of an accident and if something does happen, it is all over in an instant.

You do not have to be a scientist to figure out what might be the probable result if, running at forty or fifty miles an hour, a tire should blow out, a wheel come off or something go wrong with the steering mechanism. These are only a few of the things which can happen, to say nothing of the additional perils which can arise from other cars you may pass or meet or which, despite your warning horn, might drive out from an intersecting road and across your path.

The things which can happen are, literally, too numerous to mention. One accident, which demolished two cars and killed two people with serious injury to three others, was caused by a little fishing pole carried by a child, in a car which was met on a narrow road by another car going at a high rate of speed. The pole, sticking out at the side, struck the windshield of the speeding car, the driver dodged, his wheel swerved and the cars collided.

On another occasion, a driver going at a high speed was struck in the face by a grasshopper which flew in

at the side with the result that he lost control of the wheel for an instant, the car rammed the abutment of a concrete bridge and toppled over into the stream.

The possible complications are limitless. A car that is moving so fast that its driver can not see and easily avoid every possible source of danger, is for all practical purposes, a car out of control. A thoughtful man will hesitate to take the risk to himself and to others which such a condition entails.

The most daringly spectacular race driver this country has ever produced was being taken for a drive around one of the cities in which he was to race. On a long quiet stretch, the car was speeded up to nearly fifty miles an hour when the race driver leaned forward and urged, "Cut her down, Jack. A man is a fool to take such chances unless he is getting big money for it." Wasn't he about right?

CHAPTER IV

MOTOR CAR INSURANCE

By C. Perry, Secretary, Automobile Underwriters' Co.

The ownership of an automobile involves many hazards. In fact the only time that an automobile is free from hazard is when its gasoline tank is emptied, batteries disconnected or removed, and the car itself is stored in a fire-proof vault. Consequently the automobile owner must protect himself against the risks attendant upon the ownership of a car.

Automobile Insurance is divided into five major classifications, viz.; Fire, Theft, Collision, Property Damage and Liability. Any one of these classifications, except theft, can be bought without taking the others, but experience has taught the average motor car owner that full coverage protection is the cheapest in the end. However, some trust to luck and omit one or more of the coverages and as a result usually pay dearly for an attempt to economize.

Fire Insurance on automobiles was first written in 1902 and included Transportation, but excluded damage by fire arising within the car. Three years later this was changed and the form now in effect was adopted. The present standard fire policy covers against fire arising from any cause, and lightning; also damages resulting from collision while being transported on a railway train, steam boat, etc. The liability of the company under a policy is limited to the actual cash, or

replacement value of the property at the time of the loss. Every make of car manufactured is subject to a specific rate which is based upon the mechanical construction of the car, credit being allowed for any improvement to lessen the internal fire hazard.

The Theft hazard has been one of the most problematical that Underwriters have had to deal with. This coverage was originally written in the United States by American Companies in 1905, in connection with the fire form. Up to a few years ago it was not regarded very seriously for the reason that there were comparatively few automobiles manufactured and a stolen car could be easily identified. The present theft form covers loss caused by theft, robbery or pilferage by persons not in the employ of the automobile owner. The original intention of theft insurance was to cover the loss of the car and equipment as delivered by the factory. However, several different accessories have since been manufactured and the automobile owners have demanded that the insurance companies pay for these accessories, even though they were not attached to the car when the car was originally purchased. About a year ago losses of accessories by theft became so numerous that it was decided that it could only be reduced by eliminating all protection for accessories, and, therefore, a restricted theft coverage has been adopted by all standard companies writing automobile insurance.

The theft loss ratio during the past year has been abnormally high and rates have been increased in some sections so that the charge for this protection is almost prohibitive. The American public, as a rule, are very careless in protecting their own property. Cars are parked, without locks, in dark alleys and unlighted

streets, and the result has been the automobile thief has reaped a golden harvest from the sale of stolen cars. In addition the courts have dealt leniently with the automobile thief, in some cities, punishment being given only in a few insolated cases. A few years ago horse stealing was a hanging offense. Today automobile thievery has developed into a profitable business undertaking, and the thieves walk the streets unmolested, knowing that the law has so many loopholes that they can continue their nefarious acts without any severe punishment. The Insurance Companies are doing everything in their power to reduce losses by encouraging the manufacture of thief proof automobile locking devices, and urging their assured to equip their cars with locks. An allowance of 15 per cent of the theft premium is made when a lock approved by the Underwriters has been installed.

Collision insurance protects the car owner against damage to his own car by reason of accidental collision with another object, either moving or stationary. There are three forms of collision insurance writen, known as full coverage, $50.00 deductible and $100.00 deductible. When collision insurance was first written, in 1907, the companies were not liable unless the amount of the damages exceeded $25.00. This was done principally to prevent the companies being flooded with small claims, such as dented fenders, scratched paint, etc., but it was found that this coverage could not be profitably written for the reason that the average person reporting a loss would see to it that the damage exceeded $25.00. Therefore, the three coverages mentioned above were adopted. The full coverage policy pays for the entire loss, the $50.00 deductible provides that

the first $50.00 of every claim is borne by the assured, and the $100.00 deductible form permits the assured to carry the first $100.00 of any loss. Naturally the $50.00 deductible form is purchased more freely than the other two coverages, for the reason that the full coverage collision rate has been necessarily raised to such a figure that it is impracticable for any car owner of small means to carry full coverage collision insurance, and, therefore, he seeks the $50.00 deductible form which costs him about 60 per cent less than the full coverage policy. The rapid increase of the number of cars operated has naturally increased the hazard so that the insurance companies have been required to raise their collision rates annually in order to take care of the losses. There is not a company writing business today which has shown any profit in writing collision insurance.

The next classification to be considered is Property Damage Coverage. This coverage protects the car owner against loss resulting from damages to other peoples' property, which means either a plate glass window, another automobile, bicycle, or any other property. This coverage was first written in 1899, but within the past three or four years has been broadened to include the "loss of use" of the property damaged. This was caused by verdicts being rendered against car owners who inflicted damage to the car of someone dependent upon the use of his car for livelihood, and who might be compelled to hire another car while the damaged one was being repaired. There is no extra charge for the "loss of use" coverage, and the rate for the entire coverage is very low, being based principally upon the weight of the car and ease with which it can be con-

trolled. The company's usual liability is limited to $1,000.00, but additional limits can be obtained by the payment of a small additional premium.

The most important classification is liability insurance. It was originally written in this country, in 1898, when electric cars were first manufactured. This form protects the liability of the car owner against loss resulting from damages on account of bodily injuries, inflicted upon any person or persons, as a result of the operation of the car. The usual limits for which the company is responsible is $5,000.00 for injury to any one person, and $10,000 for injuries to two or more people in any one accident. The ordinary cautious car owner should not be satisfied with these limits for the reason that the amount of damages that may be collected is limited only by the imagination of a chance picked jury, who have probably never owned or operated an automobile. He should demand ten thousand and twenty thousand limits, which will give him more adequate protection. However, limits as high as three hundred thousand dollars can be written at a very small proportionate additional cost. Liability insurance is necessary for every car owner. The tendency of the courts is towards awarding heavy damage against the automobile driver,. Unscrupulous lawyers are making a practice of encouraging law suits for every injury caused by an automobile, no matter how slight. Large verdicts are being rendered daily. If only one class of insurance can be carried by an automobile owner it should be liability.

CHAPTER V

TRAFFIC LAWS

Although everyone is willing to concede, in principle, that traffic laws are necessary to safeguard, alike, the lives and rights of motorists, pedestrians and others, too many—if not most—motorists apparently feel that these laws are intended for the other fellow and do not hesitate to break them as often as they think they can safely "get away with it."

Every day we hear of accidents which would not have occurred if some traffic law had not been violated, but accidents do not always follow; it is seldom that anything worse befalls the offender than being caught and fined and, since it is manifestly impossible for the officers to see every violation of the traffic laws, the Chance Taking motorists usually does succeed in "getting away with it."

While the violation of these laws does not necessarily indicate moral turpitude, it does indicate a greater or lesser degree of culpable selfishness—of disregard for the rights of others—and is the cause of the prejudice against automobiles and motorists in general which exists in many rural towns and communities.

Traffic laws are simply the legal enactment of the principles of "Safety First." Self-interest alone should prompt the motorist to obey them. If through disregard of them, he should directly or indirectly cause an

accident, he will have to pay a fine and if a damage suit results, the fact of his conviction will make it easy for the other fellow to get a judgment.

In case of accident, the car owner should not leave the scene until he has obtained the names of all the parties to the accident and the names of all witnesses. He should make a diagram showing the street, the intersections, if any, the location of any street cars, wagons or other things which may have contributed to the cause, the position of the cars, the direction being traveled by each—such information, in general, as he may need in the prosecution or the defense of either a civil or criminal suit.

The traffic laws of most states and cities are very much alike and generally cover the following points:

Reckless driving shall be unlawful and shall include the following: (1) Driving any vehicle when intoxicated or when, for any reason, not competent to drive properly: (2) Driving any vehicle when it is not under control: (3) failing to exercise due care in crossing or entering the traffic of another roadway: (4) Driving any vehicle across or into a Safety Zone: (5) Driving at a rate of speed that is unsafe or inconsiderate under any conditions: Speed at no time to exceed ten miles per hour in business section or 18 miles per hour in other parts of the city.

A vehicle, on the approach of fire apparatus, shall move out of its way or stop so as not to interfere with its passage.

Drivers, to prevent accidents, must observe traffic, exercise caution and signal by out-stretched hand before slowing, stopping or backing.

Drivers, when approaching or entering a curve or corner or junction or coming to the top of a hil, if view of roadway is obscured, shall sound signal horn effectively and go slowly.

Drivers when crossing a sidewalk must go slowly and signal with horn to insure safety.

Drivers must watch for traffic officers' signal and heed traffiic signals and limit lines. Pedestrians will remain on sidewalk and wait until traffic is released by officer and move with traffic only.

One blast of traffic officer's whistle indicates that approach-

ing traffic must remain behind cross walk; two blasts indicate approach of fire apparatus or other danger.

Vehicles must be equipped with lights and horns, but horns shall not be used except for necessary signalling.

Vehicles shall not tow more than one other vehicle and no tow connection shall be more than sixteen feet in length.

Motor vehicles left standing without driver in charge, shall be left in such condition as to permit its being pulled out of the way if necessary but it must have its motor stopped and effectually secured against it being started, its emergency brake set and, if on a hill its front wheels turned in the direction of the curb. This shall not be construed to prohibit a car from being locked against theft.

A motor vehicle shall not be driven by any one less than eighteen years of age.

No vehicle shall be driven through a procession without permission of police officer and under his direction.

Everything being equal, vehicles going in an easterly and westerly direction shall have the way over vehicles going in a northerly and southerly direction.

No vehicle shall pass on the right side of a street car which has stopped to let off or take on passengers, but shall come to a halt and remain standing until street car proceeds, unless other wise directed by traffic officer.

A vehicle passing or being passed by another shall not occupy more than its share of the roadway.

A vehicle overtaking another shall pass to the right.

A vehicle overtaking another shall pass it to the left, but must not interfere with traffic from the opposite direction or pull over to the right before entirely clear of the overtaken vehicle.

On overtaking a street car, pass to the right.

A vehicle turning into a roadway, to the right, shall keep close to the right hand curb. A vehicle turning into a roadway from left shall pass around the central point of intersection of the two roadways except when directed otherwise by the traffic officer or when its turning radius will not permit it to do so without backing.

A vehicle shall keep as near as possible to the right hand curb.

A vehicle meeting another shall pass to the right.

A vehicle passing around an oval, circle or other form of centralized obstruction shall keep to the right.

A vehicle shall stop within 18 inches of the right hand curb.

A vehicle shall not stop on a cross walk nor within a roadway intersection except in an emergency.

A vehicle shall neither rank nor park nor stand so as to pre-

vent the free passage of other vehicles in both directions at the same time nor with any part of it extending beyond limit lines nor within five feet of a fire hydrant, ten feet of a safety zone, main entrances to hotels or public buildings nor within one foot a mail box nor within sixty feet of the intersecting curb line.

A vehicle shall not occupy a roadway so as to obstruct traffic nor shall it back to make a turn if doing so will obstruct traffic.

A vehicle shall not follow another too closely for safety.

A vehicle overtaking a street car stopped or stopping to take on or let off passengers shall stop and not pass or approach nearer than eight feet in any direction.

A vehicle in front of a street car shall upon signal immediately get off the track.

No motor vehicle shall be driven within the hours of one-half an hour after sunset or one-half an hour before sunrise unless there be fastened to the front end thereof at last two white lights, clearly visible at a distance of three hundred feet and a lamp or lamps so fixed and lighted so as to threw a red light to the rear and a white light directly upon its registration number.

No part of the machinery of an automobile shall be permitted to run while such vehicle is standing in any street, alley or roadway without an attendant capable of running the same.

All automobiles must be provided with effective mufflers and the same shall be kept closed at all times.

In case any vehicle injures any person, it shall be the duty of the person in charge to immediately stop and render assistance and if necessary obtain medical assistance for such injured person.

CHAPTER VI

A STITCH IN TIME, SAVES NINE

Although the manner in which a car is driven will importantly affect the service it will give for pleasure or for profit and go a long way toward determining how long it will run and what it will cost to run it, there is another factor of equal or greater importance, to which the car owner, who desires to run his car with least trouble and least expense for operation and upkeep, will pay earnest attention.

The successful, economical and trouble-free operation of an automobile requires more than a careful hand at the steering wheel or a cautious foot at the brake. Care on the road must be supplemented by care at home. It is obvious that it is possible to lose most of the fruits of careful driving through improper care or lack of care of the car.

It is, of course, a truism to say that in an automobile, as in any other machine, vibration and friction occasioned by even ordinary wear and tear will necessitate frequent adjustments, occasional repairs and sometimes even replacements. If these are attended to when the need arises, well and good; the owner will have taken his "stitch in time." Otherwise—"time cures all things," except necessary adjustments and repairs to an automobile. The longer they are postponed, the worse they get and if the owner fails to take his

"stitch in time" he can hardly blame the car manufacturer if, eventually, he has to pay a steep price for the proverbial "nine" stitches which his delay has necessitated.

"But," says some car owner, "How'm I going to know when something oughta be done?" Unfortunately, with all the "built-in" features with which manufacturers have improved their cars, they haven't yet fixed them so that they will ring a bell, blow a whistle or flash a red light when attention to some particular part is needed. Of course every rattle, squeak or other abnormal noise is such a warning, but the car owner should not wait for his car to register such a complaint. Furthermore, certain parts are "voiceless" and do not complain audibly, however much they may be neglected.

To keep an automobile running satisfactorily, the most effective thing a car owner can do is to follow the advice given in most of the instruction books published by the car manufacturers, namely, to go over it thoroughly, at regular intervals, making a thorough and systematic inspection which will enable him to find and attend to any point where attention may be needed.

But this does not mean that the car will greatly benefit from aimless tinkering. Indeed much harm can be done. The car owner must have a working knowledge of his car. He must know what parts are likely to need attention, what he can or should do to it and what parts he should leave alone. This he can learn from the instruction book published by the manufacturer of his car.

And, since some parts require more attention than others, he should lay out on a regular schedule what

things should be done every day, what should be done at weekly intervals and what can be safely left to a once-a-month inspection.

These inspections, particularly if they are made at regular and frequent intervals, will not always reveal the need of any adjustments but there is one thing that can be and should be attended to on every tour of inspection and that is LUBRICATION.

To keep himself from overlooking any part which should be inspected or lubricated, the car owner will find it of great value to prepare and put up on his garage wall, a chart indicating what should be inspected and lubricated every day, what should be looked after every week and what must be attended to once a month or at longer intervals. In making up such a chart the car owner should be guided by the instruction book that came with his car. If the lubrication instructions in the book are calculated on a mileage basis, he can figure out from his average daily mileage the equivalent in days and can arrange the chart on a time rather than on a mileage basis, allowing, of course, for proper variation if the car should be laid up or is used but seldom.

The accompanying charts might be used except in such particulars, if any, as are at variance with the instructions given by the car manufacturer in his instruction book.

The car owner will understand that such work can not be done without accumulating at least some dirt and grease. But, for compensation, let him be assured that to keep down expense, to prolong the life of the car and to keep it running at tip-top efficiency, the value of

these periodical—precautionary—inspections can hardly be over estimated.

Before tackling the job, the car owner should out-fit himself with a pair of overalls, an old cap and a pair of gloves and since he will sometimes have to "get down and get under," it would be an excellent idea for him to build himself a "creeper." This can be made of two twelve-inch boards, six feet long, fastened side by side and mounted on casters or cast-off roller skates. Thus equipped, he will be able to work to good advantage and without getting much dirtier than he would in an afternoon of golf or fishing.

Suggested Inspection Charts

DO THIS EVERY DAY

On Bringing Car In At Night:

(a) Clean, if muddy or very dusty.

(b) While engine is still warm, wipe off all accumulated dirt and grease.

(c) Inspect tires for cuts in tread or side wall, filling any found with "tire putty," "Cure Cut" or the like, following directions on package.

(d) Endeavor to locate and remedy any unusual operating noises or troubles which may have developed during the day.

Before Taking Car Out In Morning:

(a) Fill radiator with clean water.

(b) Inspect oil supply, replenishing to proper level if supply is kept at home.

(c) Inspect gasoline supply. If tank is replenished

from can and funnel is used, see that it is free from water and oil.

(d) Observe on garage floor for evidences of oil, gasoline or water leaks.

(e) Inspect springs for loose clips, shifted or broken leaves, etc.

(f) See that hub caps are tight and tools removed from running board.

After Starting Out in Morning:

(a) Test brakes and steering mechanism and see that both are operating properly.

(b) See if oil pressure guage indicates circulation of oil. See if ammeter indicates battery is charging.

DO THIS EVERY WEEK

‡ Or Every 500 Miles

(In addition to points mentioned for daily attention)

1. Thoroughly clean entire car.
2. Drain radiator and re-fill with clean water.
3. Inspect lamp wiring and connections. If necessary, remove and polish lens, light bulbs and reflectors.
4. *Inspect front spring bolts and lubricate as provided.
5. Inspect steering apparatus (steering knuckle bolts, steering gear drag link, connecting or tie rod bolts, steering arm drag link, etc.,) and lubricate as provided, not forgetting steering wheel oil hole.
6. Lift hood and inspect fan belt tension and bear-

‡If car is brand new, the oil should be drained from the crank case at the end of the first five hundred miles, the case washed out with kerosene and new oil supplied.

*If grease cups, give one turn and re-fill if necessary; if oil cups, see that they are full; if oil hole, inject oil with oil can; if open bearing or connection, apply oil or grease as specified by manufacturer.

ings and lubricate as provided. Clean fan belt if greasy.

7. Inspect operation of oil and water pumps for leaks. Lubricate water pump shaft as provided.

8. Inspect distributor shaft and lubricate as provided.

9. Inspect spark plugs, cleaning if foul.

10. Inspect wiring for broken insulation, clean off all grease and dirt; see that connections are tight.

11. Inspect all engine bolts, making sure that engine is tight on frame.

12. Inspect clutch mechanism (pedal bearings, shaft connections, release bearings, etc.) lubricating as provided.

13. Inspect hand and foot brake shaft and rod connections and brake equalizers, lubricating as provided.

14. Inspect rear spring bolts and seats, lubricating as provided.

15. Run engine until it is warm, open pet cocks and put in tablespoonful of kerosene in each cylinder and let stand over night to loosen up carbon.

In looking over car, see that all bolts are tight, and all cotter pins in place.

DO THIS SEMI-MONTHLY
Or Every 1000 Miles

In addition to points mentioned for daily and weekly attention

1. Tighten nuts on fender supports.

2. Drain crank case, clean with kerosene and refill with new oil.

3. Have battery inspected and see that cells are filled with distilled water to proper height. See that

terminals are tight and covered with thin coating of vaseline or cup grease to prevent corrosion. See that battery box container is secure.

4. Inspect front wheels for alignment and excessive play.

5. Inspect steering gear for excessive play.

6. Inspect starter-generator bearings and lubricate as provided.

7. Clean magneto externally and give two or three drops of good light oil—never cylinder oil. Otherwise, leave magneto alone.

DO THIS MONTHLY
Or Every 2000 Miles

In addition to points suggested for daily, weekly and semi-monthly attention.

1. Remove front wheels, clean and fill all bearings with lubricant specified by manufacturer.

2. Steering gear case, lubricate as specified by manufacturer.

3. Drain or clean out old lubricant in transmission gear case and re-fill as specified by manufacturer.

4. Inspect distributor contacts, wipe clean and apply thin coat of vaseline.

5. Inspect universal joints, lubricate as specified by manufacturer.

6. Inspect pinion bearings and lubricate as provided.

7. Remove rear wheels, clean bearings and lubricate as specified by manufacturer.

8. If rear axle runs in oil, drain and re-fill with amount and grade of oil specified by manufacturer.

9. Inspect brakes, cleaning bands with stiff brush

and gasoline, lubricating with a few drops of light oil. If bands are charred or worn, replace. See that hinges, cams, toggles and other brake bearings are well lubricated.

10. With switch off, crank engine by hand and test compression. If resistance is not "springy," test cylinders singly to find leak.

11. Drain and wash out radiator with soda solution, refilling with clear water.

It will not be surprising if some car owner should feel that to carry out such a program of inspection, lubrication and general care, would take up so much time that none would be left for driving. This really is not the case. Divided as it is, the work will not take up a great amount of time nor will it entail much labor or require mechanical skill or knack beyond that possessed by the average driver.

And if he makes up similar charts for his use or follows any systematic and thorough schedules of inspection, adjustment and lubrication, he will find ample compensation in freedom from troubles (including repair bills) and in a sweetly running car that will run on and on and still retain a good re-sale value after a period of service that will have sent other cars, less carefully cared for, to the junk-yard—the limbo of all neglected cars.

CHAPTER VII

TREATISE ON AUTOMOBILE LUBRICATION

By Fred J. Bedford, S. A. E., Magnolia Petroleum Co.

Lubricating System Design and Its Importance

1. The lubricating systems designed for the lubrication of automobiles must be more enduring, more positive acting, the least complicated,the least difficult to regulate, the most accessible for the application of lubricants, the most economical and more efficient than those designed for any other class of machinery ever manufactured.

2. The reason for this is simple, the automobile is operated by a far greater number of all classes of people than any other single piece of machinery.

3. The success of the automobile industry, not only demands, but the great majority of automobile operators demand it, because they do not have a sufficient knowledge of the essentials of lubrication and lubricating system for the safe and economical operation of automobiles.

Credit Due Manufacturers

4. This modern method of transportation has been in general use, in practically all parts of the United States, for the past ten or eleven years and so cleverly, in the majority of instances, have the manufacturers overcome the problems of lubrication that

the layman does not have a true conception of the importance of the lubricating requirements for economical and efficient operation.

Automobile Valuable and Useful Education Necessary

5. Automobiles are here to stay, they are just as much a part of our life as the telephone and telegraph, and it behooves every operator to better educate himself to the care and upkeep of this valuable, useful property.

6. There are those who have benefited, after paying the price of experience, but it is, in all probability, safe to say that the great army of automobile operators have not yet reached the point where they realize the necessity of devoting time and study for the most economical operation, from every standpoint, of this wonderful piece of mechanism.

7. During the period above mentioned thousands of lubricating experiments have been made with the automobile, in all classes of service, driven by all classes of people, under all conditions and subjected to examinations and investigations, for the purpose of checking and recording the cause or causes of any undesirable conditions or results.

Unnecessary Expenditures Chargeable to Improper Lubricating Oil

8. The best information available, indicates that it can be conservatively estimated, that more than seventy-five (75%) per cent of the difficulties experienced, in the operation of the automobile (barring accidents, such as personal liability, property damage and collision, theft and fire, against which one can be insured for a nominal sum, and tire trouble),

is unnecessary and can be charged against faulty, improper and insufficient lubrication, directly or indirectly; resulting in burned or worn and cut out bearings, worn gears, excessive consumption of fuel, oil and grease and excessive repair bills for labor and material, which must be replaced at the seller's price.

Unnecessary Expense Eliminated

9. A continuation of this procedure is not only an inconvenient and expensive burden, but a gross waste of material and labor because it is unnecessary and can be eliminated to a negligible quantity by the use of a proper lubricant, properly applied.

Proper Oil Necessary

10. After the layman has realized that proper lubrication is a necessity to the successful operation of his automobile, the next problem that confronts him is, what kind of oil or grease should be used, and how and when it should be applied?

Proper Lubricating Oil Defined

11. Several years ago the writer was asked by one of his friends: "What is the proper lubricating oil for an automobile?" (at that time there was only one oil company that was marketing and recommending more than one oil for the lubrication of automobile motors). His answer was as follows: "The proper oil for the lubrication of an automobile engine is one of high lubricating efficiency, one that has a body and fluidity suitable for uniform feeding under varying climatic conditions with the added qualification

of maintaining a good body or consistency, under the heated operating conditions, sufficient to form a film between the friction surfaces and seal the clearance space between the piston rings and cylinder walls, thus preventing the escape of gases during the period of compression and power strikes of the piston, without entering the combustion chamber."

One Grade of Lubricating Oil Not Suitable for All Automobiles

12. Of course the questioner was just as wise after having been informed as before the question was asked because nobody seemed to know at that time of a lubricating oil that had those qualifications, and while there are lubricating oils manufactured that will do just as prescribed in the preceding paragraph, in some automobile motors there is no oil manufactured that will do that in all automobile motors.

13. There are some motors operating, very satisfactorily, for which no lubricating oil manufactured seems to furnish ideal lubrication, and this condition will always remain to some extent, because it would be a practical impossibility to manufacture and market a grade of oil that would be ideal for each of the millions of different operating conditions. This variation of conditions may be ever so slight but sufficient to affect perfect lubrication.

A Grade for Each Condition

14. Today all of the practical, scientific automotive engineers and practically all large oil companies realize the necessity of manufacturing and using different grades of lubricating oil and grease for the

lubrication of the different classes of equipment and for the lubrication of the same equipment operating under different conditions.

. We deduce, therefore, that satisfactory and economical operation of automobile equipment is largely dependent on the selection of the PROPER GRADE OF LUBRICATING OIL AND GREASE for use in the lubricating system or systems designed for this purpose.

Determination of Proper Grades Not Without Effort

16. It has not been a very difficult matter to determine how and when to apply the different grades of lubricating oil and grease to the many different wearing surfaces of the parts that go to make up the automobile in order that oil and grease should be continually present, neither has it been difficult in most instances to determine the proper grades of grease for satisfactory lubrication where grease can be used, but to determine the proper grade of lubricating oil, for the lubrication of the motor, has been quite another problem.

Poor Lubricating Oil Costly

17. Realizing that poor lubricating oil is a costly investment, and in an effort to secure the best lubricating oil possible for the lubrication of all classes of machinery, owners and operators of industrial properties of all classes, for the past twenty years, have tried to find some method by which they would know a high grade oil for a certain purpose, in order

that they might be directed thereby in their purchases.

Available Lubricating Oil Information

18. Many of these industries have transformed their properties into automobile manufacturing establishments, and, notwithstanding the fact, many mysterious failures have occurred from the use of lubricating oil with approved specifications, that would seem to disprove the value of lubricating oil determined in this manner. There are still many who cling to the belief that a knowledge of the physical specifications of lubricating oil is the best method of determining its value.

19. The most available information has been given by analytical chemists, the data having been taken from their deliberations largely in the laboratory and consists of the physical chemical analysis of the characteristics and properties of lubricating oil.

Analysis of Physical Specifications

20. In order to reach a more definite conclusion as to the degree of reliability that can be placed upon the method of physical analysis (specifications) to determine the value of lubricating oil, let us analyze some of the facts concerning these properties.

21. The physical characteristics and properties most commonly used are, flash point, viscosity at 100 degrees F., gravity Beaume and cold test, and sometimes carbon content.

Flash Point

22. The point at which the evaporation of lubricating oil begins is its flashing point.

23. This evaporation does not begin to take place

until flashing temperatures are reached and the cohesive and adhesive characteristics of the lubricating oil govern the quantity of oil that reaches this temperature and the combustion chamber, also its efficiency as a sealing agent at temperatures slightly lower than that point; therefore, a definite flashing point cannot be determined without a consideration of other properties (viz., cohesion and adhesion) which govern its subjection to flashing temperatures.

Viscosity Consistency Fluidity or Cohesion

24. The viscosity of an oil is its fluidity or consistency, taken usually at a temperature of 100 degrees F. If the operating temperatures in a motor were alike on the side walls of the cylinders and pistons and reciprocating parts so that the thickness of an oil could be measured, this would allow the manufacturers to prescribe the proper thickness of the film of oil after certain demonstrations and tests.

25. Under these conditions a knowledge of this characteristic would be valuable but, inasmuch, as motor operating temperatures have a wide variation and the consistency of lubricating oil decreases as the temperature increases and increases as the temperature decreases, calculations of what an oil possessing a certain degree of this characteristic will perform, become a physical impossibility.

Cold Test

26. The temperatures of the working parts of an automobile motor, operating under normal conditions, in the coldest winter day to the hottest summer day range from 80 degrees F. to 390 degrees F. ap-

proximately. The lubricating oil from the crank case of lubricating systems is subjected to all of these temperatures ranging between the temperature of the oil itself in the crank case or lubricating system along the side and up to the top of the piston and cylinder walls.

27. There is only one exception to this condition and that is at the time of starting in cold weather.

Oils of High or Low Cold Test Usually Not a Determining Factor

28. When oils of high cold test are congealed in this kind of weather the only objection, that could be justly raised, is the slow circulation of oil through exposed oil pipes which compose a part of the lubricating system on the outside of the motor.

29. When lubricating oils are used of high consistency, that is, those commonly known as extra heavy oils, care should be taken to see that the oil is circulating through these pipes within four or five minutes after starting.

30. There is little liability, if any, even with the heaviest oils, for damage to occur to any of the bearings, pistons or cylinder walls because there is plenty of grease (if the oil is congealed) on them to operate the motor for several minutes without added supply, which is usually long before it is actually necessary, with the proper grade of lubricating oil manufactured from either Asphalt or Paraffine based crudes.

31. An analysis shows the consistency of the lower cold test oils is much greater than the higher cold test oils at the point where the higher cold test oils congeal, and the rate of flow of the oil, is dependent upon

its consistency and the pressure required to move either in circulating pipes would depend largely on the cohesive characteristic of the oil or grease. Therefore, it cannot be stated definitely just what cold test the oil should be for the automobile motor because the factor of consistency or viscosity, and the relative pressure required to move it in circulating systems, cannot be taken into consideration in the determination of its cold test.

Gravity

32. The specific gravity or gravity Beaume, as it is usually termed in lubricating oil specifications, has no lubricating value. It simply indicates its weight as compared with water and is used by chemists for that purpose.

Carbon Test

33. The carbon test is sometimes used and indicates the comparative carbon content of lubricating oil. There are several different methods of taking this characteristic and tests on the same oil vary from five-tenths (.5%) of one per cent to twenty (20%) per cent, but due to the fact that oils of the proper grade can usually be selected that will eliminate its presence in the combustion chamber, and the use of improper grades of lubricating oil of practically the same character, result in large quantities of lubricating oil finding its way there, it would seem there is little value of the knowledge of this property in the selection of lubricating oil.

Oils of Like Specifications Do Not Give Like Service

34. In addition to the above handicaps in the con-

sideration of the value of lubricating oil from a knowledge of its specifications, we find from practical demonstrations that two or more oils of practically the same characteristics and specifications, manufactured from different crudes, will not perform the same service; also, that oils manufactured under one process of refinement or treatment will not perform the same service as will oil manufactured under another process of refinement or treatment, even though they may be manufactured from the same crude.

35. It is also true that oils of widely variable characteristics under certain conditions will perform practically the same service.

Adhesion and Its Value

36. Chemical analysis has, in the past, and is today, the balance wheel of trade on most commodities. And the physical analysis of lubricating oil enumerated above is important and necessary in the process of manufacture, but for its practical performance it cannot be justly considered of very great value. For instance, the property of adhesion, which is not susceptible to measurement through chemical analysis, is undoubtedly as important in all probability, if not more so, than any single property or characteristic mentioned above.

37. This property is not measured by the greatest or least degree of adhesion, but the right degree of adhesion. It is this characteristic that fills up the pores of the metal, making a smooth surface between

the moving parts, and offering the least resistance to their movement.

Chemists Unable to Prescribe

38. For and in consideration of the above statements of fact, it is quite clear that it would be an absolute impossibility for any chemist to prescribe specifications of an oil to perform a certain definite service from the knowledge gained from a detailed physical analysis only.

Choice of Method

39. We operators then must choose one of the two other avenues open, the one of taking the advice of those who know, or testing the oil in our own equipment under actual operating conditions, checking the results—first for its efficiency, and second for its consumption. Continue these tests until satisfaction is secured. It can readily be determined when the best results are obtained after testing with a few of the different grades of lubricating oil recommended for automobile lubrication.

Mechanical Defects Not Cured with Oil

40. Do not try to make up mechanical deficiencies with lubricating oil—it cannot be successfully done. Perhaps temporary relief can be secured but this is always done at the expense of operation.

Lubricating Oil and Grease Guides

41. Usually lubricating oil guides and instructions are given in the instruction books that come with every automobile; if these guides are followed probably no difficulty will follow due to the application

of oil or grease. Usually a much longer period can elapse than prescribed without inconveniences, injury or damage to these parts, but these parts must have some oil or grease all of the time—every studious operator will admit this statement sooner or later.

42. For ready reference we are giving our idea of how often inspections of lubricating systems should be made for automobiles, operating under normal conditions, with a proper grade of lubricating oil and grease. The following groups consist of parts that need inspection at like periods.

Lubricating Inspections

43. The parts needing the most frequent attention are named in Group No. 1 and so on in numerical order each successive group, up to and including No. 7, includes the names of the parts that will run a greater number of miles before inspection or attention is needed than the group preceding it.

44. Even though indicators show proper levels, lubricating oil and grease containers and receptacles should be INSPECTED and lubricants applied, if found necessary, as follows:

Group No. 1

Grease cups on wheels or parts that operate in propulsion of automobile—and quantity of oil in lubricating system.—Once every day.

Group No. 2

Front spring bolts.—Once every 250 to 400 miles.

Group No. 3

Steering knuckles, spindles, arms, tie rod bolts, etc., front and rear spring shackles and rear spring

bolts, fan bearings, universal joints, clutch yoke and shifting parts, speedometer, swivel joint.—Once every 350 to 400 miles.

Group No. 4

Motor oil systems, electric generators, motors and magnetos, spark and throttle control joints.—Once every 650 to 1,300 miles.

Group No. 5

Transmission, rear axle, gear sets and brake joints. —Once every 1,500 to 2,000 miles.

Group No. 6

Steering gear, grease packed wheel bearings, battery terminals, speedometer chains.—Once every 2,500 to 3,000 miles.

Group No. 7

Spring leaves and motor disassembled making necessary replacements and adjustments when reassembled.—Once every 15,000 to 20,000.

45. Referring to and in explanation of the groups just preceding, further comments relative thereto are made in paragraphs Nos. 46 to 65 inclusive.

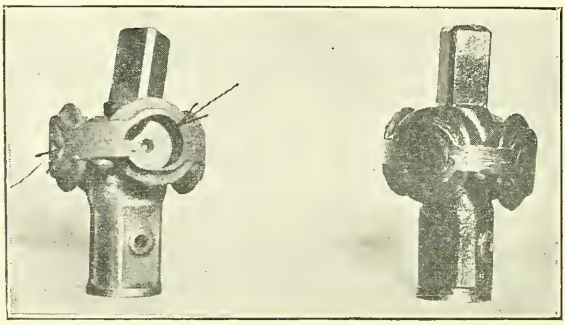
Ref. Group No. 1

46. One should always know the quantity of oil there is in the lubricating oil system—a pet cock might work open—a bolt might come out of the crank case, or a crank case gasket could leak. It takes but a moment to look over the lubricating system for indications of this character and the satisfaction of knowing always just what condition it is in, is assured.

Lubrication of Propelling Bearings

47. The parts referred to in this group should

have daily attention because the operation of the part is continual and the lubricating supply comparatively small. A reasonably thin grease should be used



Cut No. 1 shows two universal joints—the one on the left has run 1800 miles and is worn out because of insufficient lubrication —the one on the right has run 20000 miles. It has been properly lubricated and is in perfect condition. Such universal joints with proper care and attention have been known to run twelve years at a cost of approximately fifteen or twenty minutes labor and ten cents worth of grease per year.

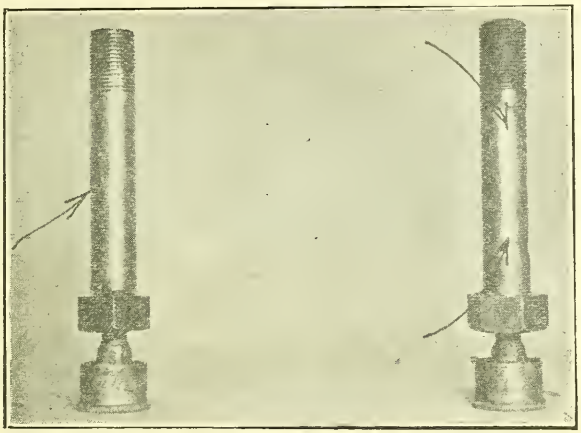
for bearings so lubricated in order that distribution will be secured and internal friction (a property of heavier grease) will be proportionately reduced. Dis-

Cut No. 2 shows two universal joint bushings—the one on the right has been properly lubricated and has run 24,000 miles and is in perfect condition. The one on the left has been improperly lubricated and has a hole worn through, practically across the entire face has run only 18000 miles.

tributors, distributor shafts, chains, etc., are included in this group.

Ref. Group No. 2
Front Spring Bolts Important

48. Only the front spring bolts are included in this group because they should not only have frequent care to insure good riding qualities of the car, but it



Cut No. 3 shows two front spring bolts both taken from equipment after having completed 18000 miles of service. The one on the right has become excessively dry and badly worn, as indicated by the arrows. The one on the left is still in perfect condition. Note the hole, that is open on the bolt on the left, it is closed in the bolt on the right, which is due to improper and insufficient lubrication.

is necessary to keep the nuts and bolts of all parts of the car from working loose, due to the additional shock transmitted to these parts when front spring bolts get dry and dirty—these two bolts have to bear a greater strain from the combined weight of the car and road vibration than any other part—they

are subjected to water, dirt, grit and dust and cup grease should be used frequently and in small quantities to keep them clean and well lubricated.

Ref. Group No. 3
Lubrication, Small Parts

49. This group covers the majority of the small parts, bolts and bearings on the car and should be inspected as outlined even though it takes a small quantity of grease, remember that it takes a little pressure at least and sometimes considerable pressure to put grease between the bearing surfaces. Where grease cups are used—it may be found necessary to relieve this weight with a jack or lever unless some very strong form of grease gun and connections are installed or available for use.

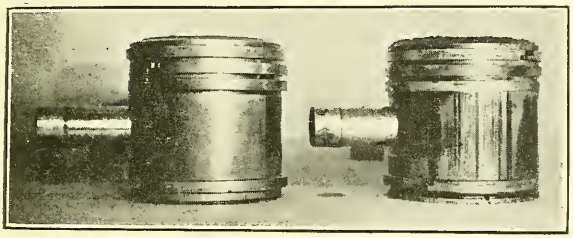
Ref. Group No. 4
Time or Mileage Not a Safe Guide

50. The lubricating oil in the system should be examined frequently; there can be no set number of miles that the car should run or any set length of time, stated before the lubricating oil should be drained from the lubricating system, but the oil should be inspected frequently. If the automobile has been subjected to muddy or dirty roads it will be found that the lubricating oil will need to be replaced very much more frequently than if operating on clean paved streets, because where dirt and dust are present a proportionate amount will be introduced through the breather tubes and other openings common to the lubricating system.

When to Change Lubricating Oil

51. When it is desired to know whether the oil in

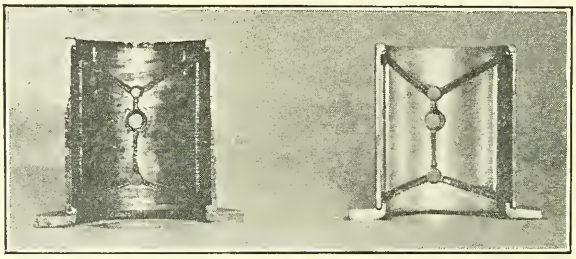
the lubricating system should be changed, the oil itself must be examined, if it is found that the oil is heavy and gritty, it should be drained out, because to continue to use the oil contaminated in this manner will cause excessive friction and wear (don't be afraid to get your fingers in it, the way it feels to your fingers is the way it acts on the moving parts of your motor).



Cut No. 4 shows two pistons. The one on the left shows the piston pin and the piston rings to be well lubricated and in perfect condition. Note where the piston on the right is scored and piston pin worn—the top of tht piston and piston rings are badly carboned, due to improper and insufficient lubrication. These pistons were taken from identical motors and run approximately 18,000 miles each. Properly lubricated automobile pistons should have a glaze which ranges in color from a grayish to a brownish cast somewhat lighter than the cylinder walls. Both should be very smooth and greasy, and objects should show a clear cut reflection on their surface.

52. If the oil is thin and feels watery it is contaminated with what is known as naphtha content. This condition (quite likely to exist in cold and winter weather) is due to incomplete combustion in the combustion chamber; the fuel, or the part of it so left, works its way down into the crank case and into the lubricating system. Oil contaminated in this

manner should be removed and replaced with fresh oil.



Cut No. 5 shows the bottom halves of main bearings of identical motors. The one on the right has been properly lubricated, has run 60,000 miles and still in service. Note the bearing surface is uniform over its entire face. This bearing is .012 of an inch thinner than when new. The one on the left has been destroyed because of insufficient lubrication after having run 50,000 miles. Well lubricated bearings made from good babitt metal should have a smooth, greasy, light grayish surface.

Cleaning Out Lubricating System

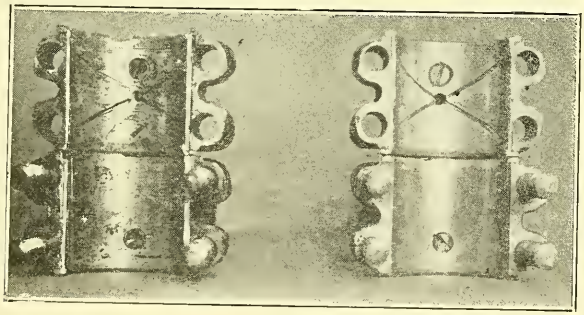
53. Do not wash crank case with kerosene oil unless the bottom of the crank case is removed, or all of the kerosene oil can be blown out with air (except the crank case be designed so that the kerosene oil will all drain out) the majority of crank cases have ribs in the block casting which form pockets as well as dipper pans which fill with kerosene oil used in this manner and lubricating oil installed in the crank case, after a procedure of this character, is contaminated before it is ever used and has very little lubricating value.

54. If the lubricating system appears to be very dirty, and it cannot be cleaned without leaving kerosene oil in the system, as referred to, it will be better to just drain the old lubricating oil out of the system

and replace with fresh oil until such time as it can be properly cleaned, because there will be less liability for injury or damage to the motor from the dirt left in the system than there would be from the kerosene oil left in the dipper pans and other parts of the system that would mix with the fresh lubricating oil and impair its value.

Filtered Oil Unsuitable for Use Again

55. Do not attempt to strain, clean or filter the oil drained from your crank case for use in your motor again. There may be some systems where this can be reasonably well accomplished but the majority of automobile operators certainly are not in possession of these filtering or cleaning systems. If the oil is reasonably well cleaned or settled it may be used for oiling throttle and spark control joints and bearings, also other outside bolts or bearings that are subjected to rain, mud, dirt and dust.



Cut No. 6 shows connecting rod bearings from identical motors. The one on the right having been properly lubricated. The one on the left improperly lubricated. The bearing on the left has run 50,000 miles and the bearing on the right has run approximately 100,000 miles without repair and still in service and is .020 of an inch thinner now than when new.

Oil Level and Circulating Important

56. After the crank case has been drained and fresh oil installed, see that the oil is at the proper level and if the lubricating system is of the circulating type, be certain that the lubricating oil installed is circulating in the lubricating oil system, which is indicated by the lubricating oil indicators.

57. Oil pumps that are reasonably close to the oil sump or suction level will prime and the oil will circulate immediately, but the oil pumps that are farther removed from this level will possibly need to be primed with lubricating oil by removing the cap from the pump and filling it, or putting the oil through the priming cock (as may be found necessary) before the oil will circulate.

Indications of Proper Lubrication

58. The proper lubrication of the motor from external sources is indicated when your motor is operating quietly and efficiently and when the lubricating oil consumption is not excessive. There can be no accurately stated amount of lubricating oil that any automobile will use, in any given time, unless it is doing identically the same work all of the time, but the quantity of the proper grade of lubricating oil consumed, is so small that it can be quite safely stated, in a medium weight automobile, should be somewhere between one gallon and one and three-fourths gallons of lubricating oil for every thousand miles traveled.

Geneerators, Motors and Magnetos

59. Two or three drops of oil will be sufficient for the electric motor, generator and magneto bearings

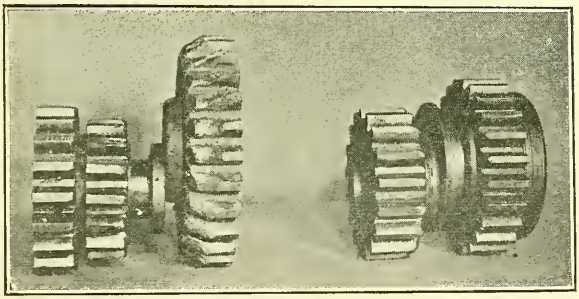
at one time. Too much oil is detrimental to the cleanliness of this equipment for its satisfactory operation.

60. Most electric generators and motors have a small, wick feeding, grease cup attached to the bottom of the bearing, this should be filled with a very light grease or pure vaseline, at least inspected, every six months.

Ref. Group No. 5
Lubrication Transmission and Differential

61. The parts named in this group should be inspected as frequently as stated because of their importance in the operation of the car.

62. Oil tight transmission cases, differential and



The transmission gear shown in the left of this cut has had the teeth worn away because of improper lubrication of the shaft and bearing, which causes the teeth to be out of line and difficult to mesh; it has run 17,500 miles. The one on the right has been properly lubricated, still in service, and is practically as good as new after having run 25,000 miles.

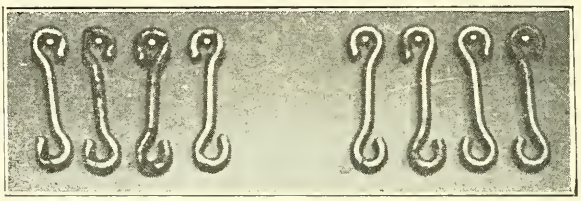
axle housings with good bearings and good felt oil retaining washers will run from ten thousand (10,000) to fifteen thousand (15,000) miles on one and one-half (1½) to two (2) gallons of the proper

grade of transmission oil properly applied—they should be drained, cleaned and refilled with fresh oil once a year.

Ref. Group No. 6

Steering Gear, Speedometer Chain

63. A thin grease is suitable for the steering worm gear, retainer, thrust and wheel bearings, also the battery terminals should be greased to keep them free from corrosion. The speedometer chain should be inspected at the intervals stipulated and greased, if found necessary. To do this the chain must be dis-



Cut No. 8 shows speedometer chain links. Those on the left have been improperly lubricated and the wear on both the outside and inside can be plainly seen. Those on the right have been properly lubricated and no wear has taken place. Both have been in operation on speedometers recording 10,000 miles.

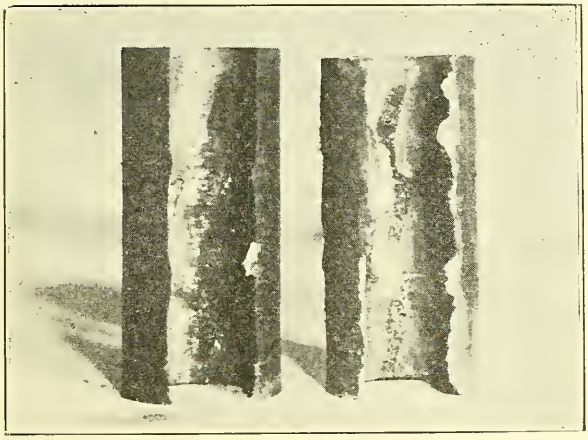
Cut No. 9 shows a comparison between a properly and improperly lubricated Timken bearing. They have both run 8,000 miles. These bearings should last the life of the car, and the one on the left has had to be replaced because of insufficient lubrication. These bearings are case hardened and should have bright greasy surface when properly lubricated.

connected, removed from the case and the grease applied to the chain, then the chain replaced and reconnected.

Ref. Group No. 7

Comfort and Convenience Available

64. The riding qualities of the car depend upon the springs, the condition of them and the spring bearings.

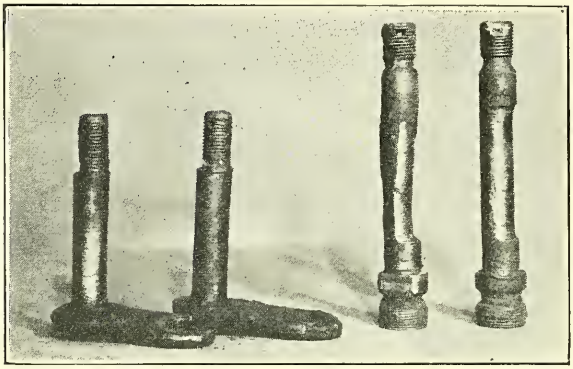


Cut No. 10—Illustrating effect of poor lubrication of spring bushings. Each of the bushings shown have run 7,000 miles. The excessive wear on the poorly lubricated bushings (to the right) is plainly seen.

65. To be properly lubricated the leaves should be separated and grease placed between them when necessary.

66. If this cannot be done, the tops, sides and bottoms can be painted with a light lubricating oil. This is only a temporary substitute and should be wiped off clean after it has penetrated between the leaves

as much as it will before draining off, which will prevent the accumulation of dust and dirt.



Cut No. 11—Both sets of the spring shackle bolts illustrated have run 7,000 miles. The bolts on the right were poorly lubricated. Observe resulting wear.

Poor Lubricating Oil Liability

67. Never use a poor or improper grade of lubricating oil or grease for the lubrication of your automobile—except—in case of absolute necessity. Of course a poor oil is better than none and if it must be used, watch it closely because in all probability the poor oil will soon be gone and very likely injured or damaged parts, due to both improper and insufficient lubrication, will result.

Proper Lubricating Oil Necessary

68. A motor is more efficiently lubricated with a light bodied oil of the proper grade, that will furnish lubrication and a seal between the piston and cylinder wall surfaces and lubrication to their reciprocating parts, than with too heavy an oil; because rapid distribution is not characteristic of the heavier oils and

dry spots, for this reason, create excessive friction and wear.

69. All working surfaces of the cylinder walls, piston and reciprocating parts must receive equal and sufficient (not too much) lubricating oil, in order to reduce internal and external friction to the minimum.

70. If your motor is overheating; if it will not pull its rated load; if there is excessive vibration; if the fuel and lubricating oil consumption is high; if the motor is sluggish or slow, it needs something and that something is, in all probability, not the fault of the design or manufacture of the machine, but the fault of the operator—either because of the lack of knowledge of how it should be operated, or because of attaching too little importance or attention to the little things that are vital.

Seventy-five Per Cent of Difficulties Avoidable

71. Remember that statistics indicate that more than seventy-five (75%) per cent of the difficulties and expense incident thereto are avoidable and chargeable, either directly or indirectly, to improper and insufficient lubrication. It would seem then, that these avoidable difficulties, at their present ratio of more than three to one, are largely due to the use of improper lubricating oil, which represents the lack of knowledge of little things that are vital, referred to in paragraphs numbers eight (8) and seventy (70).

Efficiency and How to Determine

72. In short, if efficient, economical and satisfac-

tory results are to be secured in the operation and maintenance of the automobile, the lubricating oil and grease used must be right.

73. The true test of lubricating oil then must be a practical demonstration under operating conditions and comparative results closely checked for efficiency and economy of operation, including consumption of the lubricating oil. These are the facts upon which its cost can be justly computed.

74. In the final analysis then only, is it safe to determine, the proper grades of lubricating oil that should be used, through practical demonstrations. This is important and every owner or operator should at least make some effort to determine the lubricating oil most suitable for the individual automobile in some such manner as described in paragraph seventy-three (73), the results of which are shown in the accompanying photographs.

Operators Should Be Educated To the Necessity of Practical Demonstrations

75. The preceding paragraph is not intended to convey the idea that a different grade of lubricating oil is required for the satisfactory lubrication of every automobile, because there are thousands upon thousands of automobiles of the same and different manufacture that are operating, almost identically, under the same conditions—we mean to state that the demonstrations should be made to determine which of the grades of oil manufactured is the most suitable for the individual automobile—it must be

"a grade for each condition." Not a grade for a particular class of motor operating under all conditions.

76. For instance: Two identical motors, one operating an automobile and the other operating a tractor, will require two different grades of lubricating oil for their satisfactory operation, because their operating temperatures materially differ, which affects the action of the lubricating oil—as explained in paragraphs Nos. twenty-four (24), twenty-five (25) and twenty-six (26).

77. The necessity of making practical demonstrations or tests for the purpose of determining which of the many grades of reputable lubricating oils and greases on the market more particularly lubricating oil, are the most suitable for the conditions under which any particular automobile, or set of automobiles, may be operated, should be emphasized by engineers, manufacturers and others who have made the science of lubrication a study, and in this manner their efforts will be rewarded in saving vast sums of money paid for unnecessary expense by those who believe lubricating oil a necessary evil and buy just any kind of oil first one place then another, creating all kinds of oil mixtures, considering this substitute for good lubricating oil satisfactory while the automobile runs reasonably well and in many instances if it can be used at all.

78. After the grade of lubricating oil indicated most suitable, judged by its performance and service rendered, has been chosen, do not deviate from it, except to run further demonstrations, as improvements are made in the manufacture of lubricating

oils, for the purpose of bettering conditions, if possible.

Proper Lubrication Applies To All Classes of Equipment

79. If for any reason the grade of oil found most suitable cannot be obtained regularly, it should be secured in quantities and kept accessible.

(Automobiles using the smallest quantities of lubricating oil, properly cared for by draining contaminated oil from the lubricating system, will consume from fifteen (15) to thirty (30) gallons each year. Lubricating oil, in the quantities named, can usually be purchased at a much less figure than in small quantities—for this reason, the outlay at one time can neither be considered excessive or expensive.)

80. It does not seem reasonable that there should be any exception to this rule—from the owner of the lowest priced car, who individually operates it, to the owner enjoying the last word in modern automobile elegance, comfort and convenience (a veritable palace on wheels), relying entirely on a chauffeur to operate and maintain it—all go to make up the millions expended daily throughout the United States for unnecessary expenditures—for time, labor, material, fuel and excessive lubricating oil, not to say anything of the exasperation, personal injury, mental and physical indisposition and incapacity to which the operator is subjected, and can rightfully be charged in the column headed—faulty, improper and insufficient automobile lubrication—this can be entirely eliminated by the careful application of the foregoing conclusions indicating How, When and What To Do.

CHAPTER VIII

CARE OF THE ENGINE

It is almost as important for the engine to be clean externally as for it to be clean internally. Accumulated dirt, caked with grease, on an engine is a long, long step toward corroded parts, rotted insulation of wiring and other contingent evils. A motor, like a man, will work all the better for an occasional cleaning.

If the engine is wiped off, every day, dirt will not accumulate and the engine can be kept clean. If cleaning is delayed for long intervals, the dirt will become caked and gummy. An engine should be gone over at least once a month and it and the engine compartment thoroughly cleaned. For this purpose a stiff brush dipped in kerosene can be used to loosen and remove all dirt and gummy grease. Afterward it should be wiped off with cloth moistened in kerosene. This can be done with gasoline but kerosene is better inasmuch as gasoline leaves a very dry surface, more likely to rust than when kerosene is used.

The manifold should be examined for leaks which may exist around the joints, connections or in the surface of the manifold itself, if the manifold is a casting and not made of brass or sopper tubing. These leaks may be discovered by squirting gasoline on the points under observation while the engine is running. If the engine picks up you may be sure there is a leak and that part of the gasoline has been

sucked in through it, thus enriching the mixture. If the leaks occur in the joints or connections, tighten up the joints, if possible. Perhaps new gaskets will be necessary. If the manifold leaks through pores in the casting, they may be stopped by painting the manifold with a good grade of aluminum paint. Probably two coats will be necessary and the painting should be done while the manifold is hot and the metal consequently expanded.

Brass, copper and nickeled parts should be cleaned and kept clean with a good cleaning compound of which there are many on the market. Polished iron parts can be cleaned with gasoline and can be kept from rusting by wiping them afterward and from time to time with thin oil.

Some car owners paint or enamel the entire exterior surface of their engine. For this purpose an aluminum paint only should be used. Any other paint or an enamel prevents or retards heat radiation.

It is good practice to look, every now and then, for compression leaks which are the frequent cause of sluggishness or seeming lack of power.

Compression leaks may be past any or even several of the various cylinder joints or openings such as the cylinder head gaskets, valve caps or seats, spark plugs, priming cocks, etc., or they may be due to worn, scored or cracked cylinders, cracked pistons or the piston rings may be gummed, broken or even turned so that their cuts line up.

To test for compression leaks, crank the engine by hand, with the ignition off. Hold the crank up against the pressure; if there seems little resistance or if resistance becomes decidedly weaker at once, it may be

taken as evidence of a leak in one or more of the cylinders.

Cylinders can be tested separately by opening the pet cocks on all cylinders except the one to be tested and cranking the engine by hand as above.

If the leak is in one of the joints or openings, a hissing sound may be heard. Such leaks can be surely detected by pouring a little oil around the joints and openings in turn and watching for bubbles which will be caused by the escaping gas. Such leaks can be stopped by tightening the leaking joint though sometimes a new gasket or washer may be required.

If no leaking joints or openings are found or if the compression is still poor after tightening any that are found, the trouble may be from a cracked cylinder. Such a condition will sometimes be detected by the presence of water in a cylinder after the car has been standing idle for some time. A cracked cylinder can be detected by running engine until hot, filling the radiator to overflowing, turning the engine over by hand, testing each cylinder as indicated above. If any cylinder is cracked bubbles will appear at the open radiator top.

If the cylinders are intact, the leak may be due to the valves on which carbon may have accumulated and which, in consequence, may need grinding. This can be done by the car owner; most of the instruction books tell how valves can be ground; but it is a somewhat tedious job and while it does not require an expert to do it, considerable care is necessary and the average car owner will prefer to leave it to a mechanic.

If the leak is not located at any other point, it is

most likely between the piston and the cylinder walls and may be due to worn or scored cylinders, in which case reboring will be necessary, or to worn or otherwise defective piston rings, which may have to be replaced with new.

Another reason for lack of power may be the accumulation of carbon within the cylinder where its presence will be indicated by knocking, caused by preignition.

Carbon accumulations may be caused by improper carburetor adjustment (producing too rich a mixture) by leakage of oil into the cylinder (due to badly fitting piston rings or scored cylinder walls) by filling the crank case too full and from failure to drain and renew the oil at proper intervals. However, perhaps the most frequent cause of carbon is the use of oil of poor quality or of the wrong quality for the engine.

The chances for the formation of carbon can be minimized by care but once a week, small deposits which may have accumulated, should be loosened and removed by removing the spark plugs and pouring about two tablespoonfuls of kerosene into each cylinder. This should be done after the car is brought in for the night and while the engine is still warm. After the kerosene is put in, the spark plugs should be put back and the engine cranked several times by hand with the ignition off, in order to carry the kerosene all over the cylinders. Next morning the car should be started out of doors as it will throw off a very heavy black smoke.

If the removal of carbon has been neglected for some time more thorough methods are necessary.

One car owner reports great success through use of a mixture of 90 per cent kerosene and 10 per cent wood alcohol, a pint of which he pours through the air intake of the carburetor while the engine is running with retarded spark. This is poured in as rapidly as the engine will take it without stalling. Afterwards he lets the car stand idle over night.

If carbon accumulations are heavy and of long standing, kerosene, or the mixture above referred to, may not remove them. Some of the liquid de-carbonizers may be effective. If not, the car owner should not hesitate to have the deposit removed by scraping or burning without delay.

The car owner must be careful when using kerosene or any of the liquid de-carbonizers, to see that the carbon goes all the way out; that is, that it does not stop in the muffler and exhaust pipe, clogging them up and creating a condition that is nearly as bad as the one remedied. On such occasions the muffler cut out should be opened in order to permit the carbon to escape into the open air.

Even if this be done the car owner must not assume that this muffler and exhaust do not ever need cleaning. The exhaust system is the chimney of the car and, like any other chimney, will soot up. When the system is thus clogged to any great degree the passage of the burned-out gases are impeded and create a "back-pressure" that appreciably affects the power of the engine.

Exhaust manifold, pipe and muffler should be cleaned once or twice a season, at least. The first named can usually be cleaned by fastening to a wire

a wad of cloth, soaked with kerosene and dragging it back and forth through them. The muffler should be taken apart and cleaned with a stiff brush dipped in kerosene.

A knock, which at first, may have been attributed to carbon or an improperly set spark lever, may some times be caused by a loose bearing. Such a condition results from wear which, nearly always, could have been prevented by proper lubrication. The car owner should see that every bearing surface is covered and kept covered with a wear-preventing film of oil and, in addition, in going over his engine he should always look for bearings which show signs of becoming loose. When any are found, they should be adjusted before the looseness gets worse and a condition arises which necessitates an extensive and perhaps expensive repair.

He should look particularly after the main crank, the connecting rod and the wrist pin bearings, observing now and then, after a run, if they appear hot. If so, he had better see after their lubrication.

CHAPTER IX

WHAT EVERY CAR-OWNER OUGHT TO KNOW ABOUT HIS ENGINE

By J. F. PAGE, Continental Motors Corporation.

Experience has taught us that the motorist who gets the most in performance at minimum expense is one who understands the major fundamentals of gasoline engine construction and the essentials to economical operation.

The major fundamentals of gasoline engine construction are simple. The basic principles of operation are the same in each engine. The essentials to economical maintenance and operation are easily understood.

The basic construction of an engine is governed by the essential requirements of the service in which the vehicle must operate. This can be better understood by a comparison of engines built for different purposes.

For example, passenger car engines are constructed more lightly than commercial truck engines. The elimination of unnecessary weight is a most important item in passenger car design, as lightness combined with balance contribute to comfort and performance. Weight distribution is another important item which affects directly the performance of the car. Then too, a passenger car engine is seldom called upon for its maximum power at any speed and only a small percentage of the developed power is used under normal driving con-

ditions. In design, the weight and strength of the reciprocating parts are in proportion to the resistance offered the engine when operated in average service, with a suitable factor of safety to withstand the heavy duty often encountered by passenger cars when going up hills and through bad roads. A motor of this type accelerates quickly and is usually capable of higher speeds than developed by truck motors of the same bore and stroke.

Truck engines, on the other hand, are called upon for a larger percentage of their developed power at practically all times, therefore, the moving parts are more generous in size and the engine is otherwise designed to withstand greater strains. Performance, acceleration and flexibility are not the important requirements of a commercial vehicle. There must be ample power. Dependability and long life are essentials. The engine must operate at full speed with maximum efficiency day after day for long periods of time under a great many unfavorable weather and road conditions. This calls for many adequate cooling facilities, generous bearing surfaces, and more rugged construction throughout.

Relation of Engine to Vehicle—It is not difficult for one to imagine what would take place if a lightly constructed engine were used in a heavy duty truck. The engine could be operated satisfactorily perhaps for a brief period of time, but the steady resistance offered the engine would be more than it was designed to withstand in continuous operation and as a consequence the engine would soon go to pieces or require frequent repairs and adjustments.

Place a heavy duty truck engine in a passenger car

and the chances are that the engine would give an unusual amount of service. The car would have ample power and good hill climbing ability, but acceleration would be poor and sluggish performance would result at low speed. The engine could not be operated continuously and with success at the high speed required of a passenger car engine. Furthermore, the heavy construction of the truck engine would make it necessary to build the passenger car of proportionately stronger and heavier parts, thereby increasing the total weight of the car.

The basic principles of operation are practically the same in all types of gasoline engines. It is obvious then that engine characteristics such as quietness in operation, ample power, reasonable speed ability to accelerate quickly, long life, and other qualifications which an experienced motorist appreciates can come only from refinements in design and construction—refinements that exemplify the development of gasoline engines for automotive service. Successful engines do not embody novelties. They use only successful proven practices, are simple, accessible and contain no superfluous parts.

Power, speed, acceleration, economy, and weight are considered in the design. Each of these are essential to the ideal passenger car engine, and are correctly proportioned and balanced to a remotely fine degree in order to insure durability, that necessary adjunct to a successful engine. Either one of these particular essentials can be increased by sacrificing a proportion of another.

A factor of safety is built into each engine, that is to say, the engine parts are designed to withstand

greater strains than they encounter when the engine is operated under a normal load. And too, the engine is capable of more power and speed than required in average service. Excess power is a factor of safety to be used when needed. It should not be abused.

The correct analysis of the metal in each part of an engine has been determined through intensive and extensive research, and by experiments covering long periods of time. The material analysis of any given part depends upon the general design of the engine and upon the design of the particular part. Consequently, it can be said that the design and material of each individual part are co-ordinated in the engine.

The material for each part of an engine plays an important part. The physical properties must co-ordinate with the design of the engine. The exact size and design of a part is only one requisite. The texture of the metal, hardness, strength, finish of contact surfaces, and amount of expansion, are among other factors that have a direct bearing upon the operating relationship of the parts. For this reason, it is vitally important that only parts made by the manufacturer of the engine should be used for replacement purposes. Then, only, can one be assured that the new parts have the qualifications essential to the design and construction of the engine.

When all of the essentials to a successful gasoline engine are considered, it can be seen that high grade gasoline engines for automotive purposes are nothing more or less than highly co-ordinated units incorporating minute refinements either in design or general con-

struction and that they represent development in the highest sense of the word.

Essentials to Economical Operation—Proper lubrication is one of the most important. The efficiency of an engine may be greatly impaired if operated without an adequate amount of oil.

Oil protects the life of an engine. Without oil there would be excessive friction. Friction creates heat. Heat causes expansion. The greater the expansion the greater the friction, the greater the heat. Extreme heat breaks down the lubicating film, causing abrasion. One adds to the other. When analyzed in these terms it is easy to understand what takes place when an engine is run without oil. Usually, it is seriously damaged, sometimes beyond repair.

Oil wears out. It gets thin from usage and through dilution by unburned fuel which finds its way down past the pistons into the crankcase.

The low gravity of ordinary commercial gasoline is such that an odor of kerosene can be detected when heat is applied. It is difficult to vaporize completely even when the carburetion of the engine is correctly regulated. When the mixture is too rich a certain percentage is not consumed at all, and as a result, the unburned portion of liquid gasoline, or almost kerosene, accumulates in the cylinders, dilutes the lubricant, and slowly but surely finds its way past the pistons into the crankcase.

This fuel thins the oil and takes away its lubricating qualities, causing premature wear throughout the engine.

In addition to destroying the lubricating properties

of the oil, this unburned fuel also tends to soften and free the carbon, thus making a gasoline-carbon grinding compound which has a tendency to aggravate the wear already caused by improper lubrication.

Little but regular attention is required to avoid a harmful condition of this kind. As a precaution, the oil in the engine should be drained every few hundred miles and a fresh supply put in.

It is also a good idea to watch the fuel system, seeing that the fuel mixture is as lean as possible, consistent with performance, and that the vacuum tank is functioning properly.

A gasoline engine would literally melt if some means were not provided to dispose of the heat created by the burning gasoline. The faster an engine is run the greater the number of explosions and the more heat per minute, therefore, the arrangement of the cooling system is such that as the speed of the engine is increased the cooling equipment functions to a greater degree, prevents the engine from getting too hot when used in connection with a radiator of suitable design and capacity, and at the same time keeps the temperature of the engine at the right point for efficient and economical operation.

Gasoline engines functions best after the cooling water has reached a temperature of about 160 degrees fahrenheit. For this reason the design of the cooling system has been carefully determined so that the temperature of the engine is approximately correct when the vehicle is driven at a normal speed under normal conditions. The method of cooling usually consists of water jackets cast integral with and around the cylin-

der walls and combustion chambers, a water pump, a radiator and a fan.

As the speed increases the flow of water through the radiator and motor in increased in proportion by the water pump and at the same time the momentum of the car causes a great amount of air to pass through the radiator and a great volume of air is drawn through the radiator by the fan. This air reduces the temperature of the water as it flows through the radiator and also helps keep the temperature lower by contact with the outside of the engine.

The radiator should be kept filled and the fan belt should have sufficient tension to turn the fan.

The cooling arrangement has been worked out on the basis of normal weather and operating conditions. In extremely cold weather it may be necessary to reduce the amount of air that passes through the radiator. This can be done by using a cover arranged in such a manner that the flow of air through the radiator can be regulated to suit the weather.

CHAPTER X

THE STORAGE BATTERY

What Every Car Onwer Ought to Know About His Storage Battery

J. J. King, Gen. Mgr., Standard Storage Battery Co.

During the last six or eight years the storage battery has become one of the fundamental parts of the automobile. Until very recent years the motorist has given it less thought and consideration than most any other of the vital organs in the car mechanism.

The little power plant, consisting of electric generator, storage battery and electric motor, constitutes one of the greatest improvements in motor car refinement and convenience since the first inception of the motor vehicle, yet, few owners take the trouble to familiarize themselves with the simple working principles of this important unit of their car.

The storage battery is a reservoir for storing away electrical energy to be used in lighting the car and cranking the engine. The generator which is driven by the engine when the car is in operation furnishes electrical energy to the battery which in turn absorbs and holds this power until called upon to extend it in useful work. The cranking of the engine is done by means of an electrical motor receiving its driving current from the battery.

The electric storage battery commonly used for start-

ing and lighting motor vehicles is known as the lead plate accumulator and consists of a number of individual cells or units grouped together to form the complete battery. Each cell or unit is capable of giving off an electrical current having a pressure of approximately 2 volts so that on nearly all cars batteries are used having either three or six cells giving voltages of six and twelve respectively. These have been found to be the most suitable size for this purpose and have been almost universally adopted.

Batteries vary in size, however, irrespective of their voltage, as each cell is made up of a number of lead plates and the size and number of these plates determine the capacity and endurance of the battery. The cell consists of a rubber jar in which are contained the positive and negative groups of plates. These plates alternate first negative and then positive and are connected together by lead straps. All the positive plates are connected to one strap which leads up thru the hard rubber jar cover to the positive terminal post and all the negative plates, of which there are always one more than of the positive, are connected to a similar strap leading up to the negative terminal post. Each positive plate is separated from its neighbor, a negative plate, by what is known as a separator. This consists in most cases of a thin piece of carefully selected wood which is grooved on the side next to the positive plate to allow of free circulation of the battery acid about the plate. These wooden separators are treated by different processes to remove resinous matter and other albuminous contents and they are selected with a view to their being of maximum porosity in allowing the bat-

tery electrolyte or acid to flow thru their natural pores.

The separator must be of such nature as to permit of free and easy passage of liquid or electricity from one plate to the other but its pores must be so fine that little particles of lead which slough off from the plates cannot enter and eventually form a tree from one plate to the next. This is known as an internal short circuit and in a little time will make such a cell worthless or "dead" until such time as a new separator is inserted and the battery recharged.

The plates which we have mentioned as constituting the principal part of the cell are made of lead oxides retained in a framework or grid of metalic lead. The positive plate consists of a peroxide of lead and the negative plate of a soft spongy lead, both of a very porous nature. After the plates are assembled in the cell, as told above, with separators between them, the electrolyte which consists of sulphuric acid diluted with distilled water to about 1.300 specific gravity, is added until the plates are entirely immersed. The plates immediately absorb the acid content of this solution and in a short time one would find the liquid in the cell to contain very little acid and be mostly distilled water. An electric current is now passed thru the plates and in a short time the action of this current drives the acid back into the solution.

By means of a hydrometer showing the specific gravity of the solution, the exact acid strength can be told and when the battery is fully charged it will be found that nearly all the acid that was originally put into the cell is in suspense in the solution. When this condition exists and the gravity of the solution is about 1.280 the cell is said to be fully charged and if the

charging current be discontinued and wires connected to the positive and negative terminal posts of the cell, current is given off it will be found that the acid in the electrical energy will be given off. As more and more solution is slowly going back into the plates until at last when the cell will no longer give off an electrical current it will be found that the solution has once more given up to the plates its acid content and practically nothing but water remains.

In simple terms this is the principle of the lead storage battery which is often referred to as a reversible battery. An electrical current will drive the acid out of the plates into the solution and in turn an electrical current may be generated within the plates themselves as the acid returns into their structure. With this explanation of the principle and construction of the battery the reader will no doubt have a clearer conception of the whys and wherefores of the troubles which may be occasioned in the use of his battery and should no doubt appreciate more readily the following points in the care and repair of the battery.

The Ammeter—Nearly all Motor Vehicles are equipped with an ammeter on the dash panel for indicating the rate at which the storage battery is being charged or discharged. This instrument is connected by means of a suitable shunt in one of the storage battery lead wires, and is known as a zero center instrument. When the battery is in a state of rest, the indicating hand will rest at zero in the center of the dial. Such ammeters are usually marked "'Charge" on one side of the dial, and "'Discharge" on the other, and when the battery is being charged by the Generator, the hand will move

away from zero, and indicate the amount of current in amperes which is flowing thru the battery.

In like manner when the battery is being discharged, the hand will move from zero in the opposite direction and indicate the amount of current in amperes that is being taken from the battery. The current required for starting the motor is too great to be registered on this dash ammeter, but it does indicate the current used for all other purposes. The amount of current which a battery may receive from the Generator varies with the size of the battery, and these matters are suitably determined by the manufacturer and various devices are installed which permit of only the required amount of current being sent through the battery. This rate is usually given in the hand books published by the car manufacturer, and if the driver will familiarize himself with the correct charging rate for his battery, he will be able to know at all times, by means of his ammeter, whether or not the Generator is furnishing the proper amount of current to the battery. He will also be able to tell by this ammeter when a short circuit has developed in his wiring as in such event the hand would move away from zero in the direction of discharge even tho all of his lights were turned off, and he was apparently consuming no current.

Operating Troubles and Their Remedy—The troubles generally experienced by the motorist in connection with his storage battery may usually be attributed to failure on his part to familarize himself with the few little details which are necessary to its proper working.

First, and most important, is the necessity for keep-

ing the liquid solution above the tops of the battery plates. Under no circumstance should the motorist ever add any liquid to the solution in the cells excepting pure distilled water, or clean rain water, which has been caught in nonmetallic vessels. This service is usually performed gratis by the many storage battery service stations, but can be done with perfect safety by the driver himself if he cares to do so. The constant charge and discharge of the storage battery generates a certain amount of heat and this, together with natural climatic conditions, causes evaporation within the cell. This evaporation does not extend to the more heavy acid and accordingly is entirely remedied by the addition of distilled water.

Waters containing minerals or other impurities are likely to set up chemical or mechanical action within the cell which may neutralize the acid, harden the plates and clog the porous structure of both plates and separators, causing rapid deterioration of the battery's capacity.

If the driver fails to add water to his battery, and the solution is permitted to fall below the top of the plates, the battery is not only lowered in efficiency, but excess sulphation takes place upon the exposed surface of the plate. The separator now exposed to the air soon rots and a short circuit may even develop. The only remedy will be to have the plates removed and new separators inserted followed by a long slow charge in the service station which will perhaps remove and break down the hard crust of sulphation which has formed on the plates. If the matter has gone too far,

such remedy will be so costly that it may be economy to rebuild the cell with new plates.

Much expense and trouble may be avoided and long life asured the battery by frequent and regular inspection, at least twice a month, of the level of the battery electrolyte or solution.

Second in importance to watering the battery is the matter of keeping the battery charged. Storage batteries are very similar in this respect to animals and human beings. They must be fed whether they are working or not.

Many motorists imagine that when the car is put in storage for a period of three or four months they are doing the battery a real kindness by permitting it to rest. This, however, is not the case, and the battery's life and vitality depend upon its use and action. When the battery is fully charged very little deterioration is taking place, but if charging is discontinued, the battery immediately starts discharging of its own accord, and if given no further attention would eventually become completely discharged. Batteries in a discharged condition are subject to excess sulphation, and if allowed to remain too long in this condition, will reach a state from which they are beyond economical recovery.

It is therefore very important that the battery be retained in a charged condition. This condition may be determined by a visit to the nearest service station or may be had by the motorist himself with the aid of a battery hydrometer. Nearly all battery hydrometers are marked to show three states of the solution which reflect that the battery is either charged, half-charged, or discharged. When the hydrometer indicates that specific gravity of the solution is from 1.250 to 1.300,

the battery may be considered in a normal condition, the customary reading for a fully charged cell being 1.280. When the gravity reads less than 1.200, the danger point has been reached, and the battery should receive a charge from external sources. This may indicate that the starter is being excessively used or that a great deal of night driving is done in which event the generator has been unable to supply enough current to the storage battery to make up for the excessive demands. It may also indicate that the generator is not charging properly and should be tested.

Before leaving this subject, it might be well to mention the fact that trouble is sometimes incurred by overcharging as well as undercharging. The protective devices mentioned above may not compensate for all conditions, and on long trips where the starter and lights are used infrequently, the battery is likely to receive too much current. This condition may be remedied by permitting the head lights to burn for an hour or more each day and on such prolonged journeys, it will be well to make more frequent inspection of the level of the solution in the cells.

Third in importance in the care of the battery and perhaps equally as important as the two subjects previously mentioned is the matter of keeping all terminal and wiring connections snug and tight. Poor contacts and loose connections not only make for trouble in starting the motor and for dim lights but also retard the battery from being properly charged and if the connections are loose in the battery terminals themselves it may lead to more serious trouble. Loose connections at these points cause the cable to whip about and sometimes loosen the post and its seal from the rubber top

cover in the cell. This shortly leads to damaged separators, perhaps plates broken off from the connecting straps, which leads to a short circuit and a "dead" cell.

Then too, there is the further danger of fire, as these loose connections sometimes get very hot and give off electric sparks which have been known to ignite oil soaked parts of the car causing disastrous loss.

It is also important to keep the battery and terminals clean as the efficiency of a connection is lowered by corrosion. Acid, which is sometimes spilled in testing, soon eats into and rots the case if allowed to remain. Occasional washing with soda water followed by clear water will insure longer life to the case, while the terminals may be kept clean by a coating of vaseline.

These are the most important points to be emphasized and remembered in the care of the battery, and while there are troubles which develop from other sources, careful records maintained in large battery service stations have shown that more than 95 per cent of all premature battery ailments are brought on by one of the afore mentioned causes. If the reader will comply with the cautions mentioned above it can be safety said that his battery will far outlive any guarantee which the maker has seen fit to place upon it.

In general then, it will be well to keep an eye to the water level in the cells, to look to the ammeter to see that battery is charging properly, and to make certain, by hydrometer test, that the battery does not reach and remain in a discharged condition.

The purpose of this article is to give the actual user of the storage battery a little insight into its workings, and to caution him in the few essentials of care which will make for long life in his battery. No effort has

been made to touch upon the unusual occurrences such as broken jars or jar covers, or other matters which must be left to the service station for repair.

As a closing paragraph to this article, the writer would like to impress upon the motorist the value and importance of the service to be rendered by the average storage battery service station. No doubt many of us have had a costly experience with our storage battery and have then and there declared that those people engaging in the storage battery business were "ruthless profiteers." It strikes a rather painful spot when some day we are compelled to spend a twenty dollar bill or maybe two, to remedy something about our car which we have given the least of thought and consideration.

The majority of these stations render service which is invaluable to the motorist, and aside from the service of adding distilled water to the cells, they test the battery and are able to advise the customer the best course to pursue in securing a maximum of usefulness and life from his battery.

Naturally, the service station man, by such service, expects to secure the motorists business at such time as he may require a new battery, but he is nevertheless prolonging the life of the car owner's battery, to the best of his ability.

On the whole, the service station man is worth getting acquainted with, and by judicious use of his advice and service, your battery cost may be reduced to the very minimum.

CHAPTER XI

THE FORD TIMER

Troubles—How Detected—How Remedied—How Avoided

By Ian. E. Maltby, Milwaukee Engine & Supply Co.

Fully 90 per cent of the trouble which Ford owners have with the timer or commutator is due to neglect. Properly and regularly cared for, a good timer is an amazingly durable little instrument, functioning perfectly for thousands of miles, and finally giving due and fair warning before it calls for replacement.

Timer troubles are not hard to detect, although the beginner often confuses them with carburetion difficulties. Hard starting, skipping or misfiring when under load, popping and muffler explosions at high speed are the commonest symptoms of a defective timer.

Generally speaking,timer troubles are remedied only by replacement, as it seldom pays to attempt to repair a timer which is so inexpensive to replace. In replacement, too much care cannot be exercised in the choice of the instrument purchased. The complicated types, of which there are many on the market, are no better buys than cheap unbranded timers. And for the same reason—they lack durability. Quality of materials and simplicity of designs are the prime requisites of a timer for the Ford, for it must be remembered that

the average timer functions under disadvantageous conditions at all times—usually in a mess of dirt and grease.

If the instrument itself is good, most timer troubles can be avoided by periodical cleaning and oiling. On installation, a timer should be thoroughly flushed with light engine oil of good quality. It should be freely oiled thereafter every hundred miles or so. A good plan is to oil it once a week. Every 500 miles—or once a month—the timer shell should be lifted out, thoroughly cleaned with kerosene, then oiled and replaced.

If the timer is allowed to run dry, rapid wear of all moving parts naturally follows. It has also been found that a metallic ridge will form on raceway and roller which materially interferes with proper ignition. Failure to clean the instrument at intervals will cause it to become gummed up with a mess of old oil and dirt until finally electrical contact is entirely prevented. Misfiring is usually due to the raceway having become worn and wavy so that the roller touches only parts of the contact or jumps some of them entirely. This misfiring at high speed is evidenced by repeated popping and explosions in the muffler.

Bumpy raceways are oftimes caused by water dripping on the timer from leaky radiator hose. This water swells the fibre out of shape, thus raising the fibre to a greater level than the contacts. Regardless of the quality of the fibre used it will swell when subjected to water in this way. Cheap timers are also often subject to loose contact points which often cause aggravated misfiring. In the finer instruments the

contact points are imbedded in machined grooves and cannot loosen.

The importance of a smooth, clean raceway and a correctly aligned and well oiled brush assembly will be appreciated when it is recalled that the timer roller makes 2,442 contacts per minute—40 per second—when the car travels thirty miles an hour. Yet each contact must thoroughly saturate a coil unit so that the low magneta current of less than 18 volts can be stepped up to the 5,000-15,000 volt "'Juice" that fires the cylinders.

Some job that little timer has to perform! That is why it pays to buy the best you can get and give it regular care.

CHAPTER XII

THE FUEL SYSTEM—ITS CARE

The fuel system (gasoline storage tank, gas line, vacuum tank—if the car is thus equipped—and the carburetor) requires little routine attention beyond seeing that all connections are tight and pipes open (storage tank to vacuum tank—to carburetor—to inlet manifold) and that sediment and water are removed from the points where such accumulations are possible.

Such accumulations can be drained from the storage tank by opening the cock on the bottom of the tank provided for that purpose. Once or twice each season it is a good plan to drain the storage tank completely, particularly if the gasoline should seem to contain much water. After draining, the gasoline can be strained back into the tank through a chamois skin to separate the water. Water and sediment should be removed frequently in winter, particularly if the car has a sediment bulb as it may fill with water and freeze thus stopping the flow of gasoline. Similar trouble may sometimes be caused by water freezing in the carburetor. In either case it can be remedied by wrapping with cloths wrung out of boiling water, thereafter opening drain cocks to permit accumulations to escape.

Once every two or three months, or oftener if the motor should begin to misfire, pop or sputter, the

filter plug or screen of the carburetor should be removed and cleaned. Before the car owner does this he should be sure he knows exactly how to do it and should be particularly careful not to disturb the carburetor adjustment in any way.

Every five or six weeks the strainer screen of the vacuum tank should be cleaned. Every five hundred miles the vacuum tank should be drained.

Once every season, or oftener, if need should occur, disconnect the gasoline feed line and remove any accumulated sediment. This can be done very effectively with compressed air. This is particularly advisable if the pipe has any bends or depressions where sediment would naturally accumulate. In replacing, care should be taken not to cross any threads.

Leakage of gasoline from any source is not only wasteful but dangerous and should be stopped at once. Such leaks may be due to gas line connections having become loose from vibrations. In such case the remedy of course is to tighten the connections. Possibly also it will be necessary to put in new gaskets. Be sure not to cross any threads and be equally careful not to exert enough pressure to crack the line. A crack in the gas line should be soldered at once but a make-shift repair can be made by plastering the orifice with brown soap, held in place with a wrapping of tire tape. A little better repair and one which may suffice even if the line is actually broken in two, is to cut a sufficiently large strip from an old inner tube and bind it tightly around the break with wire.

A small or occasional leak at the air vent of the vacuum tank need not occasion any alarm or call for

any adjustment. If, however, it continues to overflow, possibly the air hole in the storage tank is stopped up. Leakage in the vacuum tank may also occur at the head of the tank or at the carburetor connection. If the former is the case, it may be remedied by removing the cover, being careful not to injure gasket, cover the gasket with shellac and replace.

After removing and replacing the cover of the vacuum tank the tank can be refilled by turning the engine over a few times with the spark off and the throttle closed.

A leak at the carburetor is possibly due to a small particle of dirt having lodged under the flat needle valve. By opening the valve half a turn back and forth a few times, the obstruction may pass through. Or the valve may be opened half a turn and the throttle lever given two or three quick pulls, returning the valve exactly to its original position. If it is due to a leaky valve the trouble may be stopped by a few VERY light taps on the top of the valve stem, thus causing the valve to seat properly.

If this does not stop the overflow the needle valve may be defective and will have to be replaced or the trouble may be due to the float which, if cork, may have become gasoline soaked or, if metal, may have developed a leak which may likewise prevent it from floating. In either case a repair is necessary which the car owner will do well to leave to a more experienced hand.

Leakage and overflow, due to flooding is about the only obvious and unmistakable carburetor trouble. If any trouble develops which causes the car owner

to suspicion that all is not right with his carburetor he should have his suspicion well confirmed before adjusting it himself or permitting any one else to do so. Every other possible cause should be thoroughly tested out before the carburetor is disturbed. In any search for trouble make the carburetor the last place to look and the last part to touch.

Carburetors are tested and set and adjusted before the car is delivered to the purchaser and it is seldom indeed that any further adjustment becomes necessary. Many times adjustments are made when adjustments are not called for and such tend to aggravate the trouble for which a remedy was sought or cause additional troubles of a different sort.

The necessity for an adjustment that will change the composition or quality of the mixture will not arise suddenly. If the car has been running satisfactorily it is most unlikely that the carburetor is the seat of any suddenly developed trouble.

Adjustments may possibly become necessary and if the trouble can not be found elsewhere the car owner can open the priming cock of a cylinder and get a good line on the product of his carburetor by observing the color of the flame. If it is correct, the flame will be blue; if over-rich, it will be red; if too lean, it will be white. The car owner must remember, however, that a mixture apparently too lean, may have been correct when it left the carburetor but may have been weakened by the admission of air through some leak in the inlet manifold or connection.

After the need for some adjustment is definitely and unmistakably established, it can be made in a few minutes by any one who really knows how. The

car owner can do it if he has studied the chapter on carburetors in the instruction book that came with his car or if he has at hand an instruction book published by the manufacturer of his particular make of carburetor. But unless a carburetor is to be adjusted with absolute correctness it had better be left alone and since an experienced mechanic can make the necessary adjustment in a few minutes it will be real economy for the car owner to leave the job to the service station maintained for his car or his carburetor.

With a correctly adjusted carburetor the next factor toward fuel economy is care in the purchase of gasoline, a matter of real importance now that there are so many refineries and the market is so full of gasoline of so many varying grades and qualities. A simple test of the quality of gasoline is to pour a little in the palm of the hand. If it evaporates quickly, leaving the hand dry, its quality is good. If it evaporates slowly and leaves a watery or greasy residue, the quality is low and should not be used.

In buying gasoline, as in buying anything else, the car owner will save money—and trouble—by seeking the product of a well known and reputable manufacturer.

Gasoline, particularly of the lower grades, is likely to contain more or less water, and other impurities to which may be traced most of the troubles of the carburetor and other parts of the fuel system. Despite the extra trouble entailed, gasoline should always be strained through a chamois skin into the tank. If this be done, be sure that the funnel fits smoothly into the intake vent of the tank, thus creat-

ing a "ground" and preventing a spark from the static electricity generated by the passage of the gasoline.

Exhaust fumes contain a deadly gas which causes asphyxiation and death without warning by odor or preliminary symptoms. For this reason a car should not be permitted to run in a closed garage. If one must work about a car while it is running the car should be in the open air or the garage doors kept open.

If gasoline should catch fire do not run from it and do not attempt to put it out with water. A wet blanket or sand or anything that will shut off the air will do the work effectively. All cars and every home garage should be equipped with a chemical fire extinguisher.

CHAPTER XIII

THE CARBURETOR

Troubles Caused by—How Corrected Care of

By V. I. Shobe, Zenith Carburetor Co.

Although the carburetor is a most essential part of the equipment of every automobile there are perhaps many motorists who understand little or nothing pertaining to it.

In order to obtain energy from gasoline it is necessary that it be mixed with a definite volume of air before it can be exploded in the cylinder. This mixture together of gasoline vapor and air is called "carburetion" and the device that keeps the two in proportion is called a "carburetor."

Primarily, all carburetors are the same, in that they have but two functions to perform, viz., to supply the proper proportions of fuel and air and to deliver a homogeneous and finely divided mixture to the engine.

All carburetors of the present day design have been evolved from the simple mixing valve consisting of an air passage containing a single jet. Because this simple type cannot supply the proper mixtures for the engine throughout its full speed and power range, it has been necessary to adopt various modifications that will compensate for and provide the mixtures required. These modifications are reflected in at least twenty-four distinct carburetor types. Of those now on our

market, all but one are of the adjustable type and require frequent attention to keep them operating efficiently.

Three prominent chemists of the U. S. Bureau of Mines recently made some important tests of the composition of automobile exhaust gases. The conclusion at which they arrived was: That of every gallon of gasoline used in a motor car nearly thirty per cent is wasted through faulty carburetor adjustment resulting in imperfect combustion. The average motor car owner doubtless knows all too well that his car wastes gas. Consequently, when your carburetor is one of the adjustable type, much importance should be given to its careful adjustment in order that the common troubles caused by having either too rich or too lean a mixture may be remedied.

This caution should be given: Before attacking your carburetor as the cause of your troubles be absolutely certain that it is your carburetor that is at fault.

Your carburetor adjustments should be made only after the engine has been running long enough to reach its normal operating temperature. Be sure that all the spark plugs are clean and set at the proper gap. Also make certain that the ignition system is in perfect order, timer contacts clean, and that you have a spark at each cylinder. The fuel tank and piping should be clean and clear and all manifold connections between the intake valves and carburetor must be air tight.

Carburetors of the adjustable type vary so greatly in their construction and in their methods of adjustment that it is impossible to suggest a universal remedy for adjustment troubles.

With every motor car a hand-book or manual as to

the care and operation of the car is given. Study this carefully and follow the directions given for the care of the particular carburetor used in your car. If you do not have such a manual, a booklet dealing with the care of the carburetor can usually be furnished by the manufacturer. If unable to solve the adjustment problem yourself do not hesitate to call on your garage man.

Carburetors of the non-adjustable type such as the Zenith have spray nozzles or jets with fixed openings instead of the needle valve. If found necessary to change the factory adjustment of this type of carburetor, it can be accomplished by unscrewing the nozzle and replacing with another size. This is generally unnecessary as the correct sized nozzles are fitted to the carburetor when the engine is tested at the factory.

Two of the principal causes of carburetor troubles are dirt and water.

Small particles of dirt will clog up certain small passages in the carburetor. Water condensation often appears in the carburetor causing rust and scale to form which may interfere with the flow of the gasoline. Water reaching the jets and passing through into the motor will cause spitting or backfiring and may even prevent the engine from running.

The proper care of your carburetor should include its draining once a week and occasionally a thorough cleaning of all parts. Special attention should be given to see that the screens are kept clean. In order to get rid of rust and scale the carburetor should be taken entirely apart and all impurities blown out by means of an air line.

The carburetor float is an occasional source of trouble. If the float is of cork it is apt to become gas-log-

ged and sink, causing a slow leakage of gasoline when the car is standing. This fault can be remedied by putting in a new float or by cleaning the old float with alcohol and painting with a thin coat of shellac after it has been thoroughly dried out.

A metal float sometimes become punctured. This is usually caused by rough handling or accidentally dropping the float. To discover whether or not it has been punctured—when in doubt—submerge the float in hot water. If gasoline has collected inside of the float, the hot water will vaporize it and its presence will be detected by bubbles as it escapes from the float. It is better to replace a defective float with a new one rather than to attempt to repair it.

If you are unable to discover the cause of your carburetor trouble, you should consult your garage man at once. Perhaps a wornout part should be replaced.

In conclusion, it should again be stated that owing to the many different kinds of carburetors it is impossible to give a "cure-all" for all carburetor troubles.

The vital importance of keeping your carburetor as as clean as possible can not be emphasized too strongly. As stated previously, it is quite advantageous to drain your carburetor at least once a week.

CHAPTER XIV

THE COOLING SYSTEM—ITS CARE

In water cooled engines, the first requisite is an ample supply of water in the radiator at all times. It should be kept full all the time with clean water, the softer the better. Muddy water clogs up the passages with sediment. "Hard" water causes a scale to form, with the same result. The best water for the radiator is rain water.

Clogged water passages is a frequent cause of the overheating of the engine. This can be retarded by frequently draining the radiator and refilling with clean water.

Scale and sediment can be rather effectively removed by the use of a solution of one-half pound of cooking soda thoroughly dissolved in three gallons of water. Drain the radiator, put in solution and let engine run for about three hours, remove, flush circulation system with clean water, drain again and refill, with clean water.

If the car has forced circulation system, the cleaning solution and the loosened scale and sediment can be best removed by disconnecting the upper hose and letting the engine pump the solution out, at the same time running clean water in at the top of the radiator as fast as the engine pumps the dirty water out.

If the car has the thermo-syphon system, remove upper and lower hose connections after running

the engine with the cleaning solution and wash system out with clean water by flushing with garden hose inserted at upper hose connection at top of radiator.

See that hose connections are tight and that the hose is properly put on. Sometimes a loose lining inside the hose almost completely shuts off the circulation.

Be very careful not to replenish the water in the radiator while the motor is hot. If the cylinder head is so hot that the hand can not be held on it with comfort, wait until the engine cools before adding water. It will not require many minutes for the motor to cool and the time lost in waiting will be more than offset by the lessened danger of a cracked cylinder by putting cold water in a hot engine.

Watch for leaks in the radiator. An overlooked leak may drain out the water before the driver knows it and as a result the engine may sustain serious damage from the consequent overheating. When a leak is discovered, the car owner should be very cautious in attempting to stop it with any of the patent preparations sold for that purpose. Before using any of these he should test its solubility. If half a spoonful or so of it will thoroughly dissolve in a cup of water, it can be used without danger. He should not use any preparation that contains meal or any other insoluble substance. **These may stop the leak but they** are almost sure to also stop up some of the water passages, thus impairing the efficiency of the radiator. Sometimes a temporary repair can be made with a piece of chewing gum. Sometimes a coating of stiff white lead will stop small leaks. The only advisable course

to pursue when a leak occurs is to have it permanently repaired by a competant repair man.

If a car is not equipped with adjustable shutters, to regulate the passage of air through the radiator in cold weather, it would be a good idea to purchase a hood cover for winter driving. Sometimes a similar effect can be had by tieing a piece of cardboard across the front of the radiator. When this is done, however, not more than half the surface should be covered.

To prevent freezing of the radiator in winter, fill the radiator when cold weather sets in with an anti-freeze compound. Alkaline mixtures should be avoided as these tend to deposit a sediment that clogs the water passages. The best mixture to use is one that contains the following:

17 per cent Alchohol
13 per cent Glycerine
70 per cent water

Additional alcohol should be put in every few weeks to make up for amount lost in evaporation. Any anti-freeze mixture should be removed as soon as warm weather comes and the circulation system cleaned in the manner already described.

Should the radiator freeze, do not attempt to thaw it by running the engine. Better drive the car into a warm garage and apply hot water to the bottom of the radiator until absolutely certain that water is circulating freely.

To prevent exterior rust, it is a good idea to have the radiator painted but the paint should not be applied so heavily as to clog the interstices as this lowers the ability of the radiator to throw off heat. For

the same reason, mud should not be allowed to remain on the front of the radiator. Do not attempt to wash this off with a hose from the outside, however. Better raise the hood and wash off from the inside, being sure that no water gets to the magneto or timer.

Take a look every now and then at the fan, seeing that the bearings are lubricated and that the tension is tight enough to enable belt to turn fan properly. Clean the belt every now and then of any accumulated grease and dirt. This can be done with a stiff brush dipped in gasoline.

If the car has a forced circulation system, it may be necessary, occasionally, to tighten the nut on the pump shaft in order to stop leakage. If this does not stop the leak, unscrew the stuffing box and re-wrap shaft with ordinary candle wicking, well coated with graphite and tighten nut again. The wicking should be wound around the shaft in the same direction as the nut tightens.

CHAPTER XV

PISTON RINGS

Their Manufacture, Installation and Service.

By A. J. Mummert, Chief Engineer, McQuay-Norris Manufacturing Co.

Piston rings are light springy bands of iron that fit into grooves on pistons of gas engines, and keep the gases from passing into the crank case. They are made in a variety of forms—ranging from the one-piece concentric ring which is generally used by manufacturers in new motors, to multiple piece rings made up of seven or eight pieces which are used principally to meet replacement field conditions.

More than fourteen hundred patents have been taken out on the subject of piston rings, which gives one an idea of the wide range of effort which has been made in this one element of the automobile field.

Piston rings are made of gray iron for the same reason that cylinders and pistons are made of this material. It is because of good wearing quality in cast iron. In reality a piston ring is a spring that would ordinarily be made out of steel, if the wearing quality were not so important. Steel is very strong and makes a good wearing surface under certain conditions, but cast iron is a much more suitable material for the reciprocating action in cylinders and pistons on account of the free graphite contained in the structure of gray iron. This graphite, which is very similar to the lead in a pencil,

acts as a lubricant between the surfaces and permits pistons, cylinders and rings to perform much better with regard to wear than if they were made of steel. Any grade of gray iron has a certain percentage of this carbon or graphite matrix with its lubricating qualities, but piston ring iron must be very elastic and strong as well, and on that account a great deal of effort is made in the selection of materials, the melting, refining and casting of the iron.

The most recent improvement in the making of gray iron for piston rings is the use of the electric furnace, which makes the process expensive, but produces a vastly superior product.

Manufacturers of automobiles, almost universally, use a single piece concentric piston ring. They can do so, because when the engine leaves the factory the cylinders are perfectly round, true and straight; the pistons are a tight fit, and all of the conditions surrounding the rings are ideal. Therefore, in original factory installations the one piece ring is very satisfactory, especially in view of its economy, because it can be made so much cheaper than can the special types that are used in the replacement field.

After the car has been driven ten or twenty thousand miles, cylinder conditions change somewhat according to the locality in which it operates. If the car is driven in a rural district on dirt roads, the piston ring wear will be considerably greater than the same car used in city traffic continually where the dust is not so serious.

It must be remembered that the average small car draws in, roughly, 150 to 200 cubic inches of air every other revolution, and with the air the dust that is carried in will be deposited in the cylinders. There it acts

as a mild abrasive and produces excessive wearing of the parts. The cylinders, pistons and rings are the first to have contact with this abrasive material. Since the piston operates with a pressure in two directions only, we can expect the greatest wear to follow accordingly, and on that account cylinders wear oval or egg shaped with use. This wear, of course, is measured in thousandths of an inch, not fractions of inches, and while it is comparatively small, inside micrometers will show its presence. Pistons get smaller and the cylinders get larger. Eventually some cylinders have to be rebored and new pistons replaced, but this is very often not until thirty or forty thousand miles have been run.

In the meantime, piston ring replacements that are made with a view of correcting gas leakage and oil pumping are subject to more severe conditions than the rings originally placed in the car. These replacement rings must be flexible and they must make up for the lack of packing efficiency that the original tight fitting piston and cylinder had. They must also pack tightly against the greater oil flow that is now passing through the larger clearance between the cylinder and the piston.

These conditions are responsible for the variety of constructions that are found on the market for replacement purposes. One type is for the car that is pumping oil excessively; another has points in its construction which makes it very flexible, etc.

In all of these constructions, however, a common effort has been made to produce three or four important effects. A ring must press out against the cylinder wall with a definite pressure, and this contact with the cylinder should be uniform around the entire circum-

ference of the ring. The rings must fit properly in grooves that are true, because it is not the tightness of the ring in the groove that packs the piston, but the manner in which the side surface of the ring and the side of the ring groove make contact. If these surfaces are true, then the ring due to friction caused by the piston moving up and down acts like a valve or a gasket when packing against gas leakage.

It matters little what feature is placed upon a ring—if the above mentioned points are not handled properly, the ring will not be satisfactory.

The necessity for piston ring replacement in a motor car is not always clearly indicated to the user. The process of wear and increasing inefficiency, due to worn rings is gradual. The increasing fuel consumption and oil consumption, and the decrease in the power ability is gradual and most drivers are unaware of these changing conditions until they have to shift gears on smaller hills, or clean sparks plugs at frequent periods.

Considering the great difference in fuel and oil economy that is occasioned by piston ring wear, it would be economy in the long run if some definite time could be set in which the rings were changed periodically—say every ten or fifteen thousand miles. A great many people imagine that if the surface of the ring looks bright and shiny it is in good condition and can be left until the next shopping of the car. The thickness of a piston ring and its deflection when compressed determines its pressure against the cylinder and since the thickness is reduced gradually but steadily with wear, it is very easy to find rings polished on the face, but worn to three quarters or half their original thickness. This lack of pressure not only allows gases to pass the

piston reducing the effective pressure on the piston, but they also permit an excessive amount of oil to reach the combustion chambers.

The best test for a motor car is a slow speed operation against a good grade. Motors running at high speed on level ground do not require the packing efficiency that they would when pulling hard at slow speed. The leakage possibility is the same in either case, but the time element is so short that the loss does not amount to a large volume on each stroke.

If an owner can take his car out and pull a grade at slow speed on high as well as when the car was new, then he can be fairly sure that there is nothing wrong with his piston rings, provided his oil consumption is just as low as when the car was new.

The increased oil consumption in motor cars in the last few years has become a decided problem for owners. This trouble is increasing in spite of better piston rings, better engine design and better materials. It is due largely to the demand for overpowered cars. The average motor car requires about one fifth of its total available power to propel it along a level road at twenty miles an hour. The only way that the car can be held to twenty miles an hour is by throttling the engine. When an engine is throttled there is a considerable vacuum on the suction stroke and a subnormal compression and explosion. The light pressure down have a lesser effect in keeping the oil back than if full pressure were in force and the vacuum is drawing oil upward toward the combustion chamber.

The more reserve power we put into an automobile, the tighter we must close the throttle for a given speed and the public demand for reserve power in the modern

automobile makes it impossible to check this trouble by a change of design.

Piston rings are a big factor in oil pumping and unless a poorly designed oiling system is responsible for the trouble, an economical and quick remedy is possible with new piston rings.

The specifications covering the ordering of piston rings for used cars are quite important. There is a tendency for repairmen and owners to over-estimate the wear in their cylinders and grooves. The diameter of the piston ring should be the same as the diameter of the cylinder in which it is to operate. Any diameter or width can be obtained and the rings should always be ordered according to the diameter of the cylinders. The width of a ring should be such dimension that the ring shall be free in the groove after it is installed on the piston. This amounts to about one-half thousandths clearance between the side of the ring and the ring groove. In many cases the groove is worn so that its bearing surfaces are no longer true with the piston. In such cases the groove should be trued up in a lathe, widened in this way and a ring width one thirty-second oversize should be purchased. Rings slightly oversize in diameter also should be purchased, and careful measurement of the cylinders will give the exact oversize which is needed.

At the prevailing prices of gasoline and lubricating oil it is not difficult to figure the short time that it takes to save the cost of replacing piston rings, to say nothing of the comfort of better acceleration, better hill climbing ability and smoother operation.

CHAPTER XVI

THE CARE OF THE CLUTCH

For a clutch of any type to last long and work properly, it must not only be correctly cared for and adjusted when adjustments are necessary but it must also be used intelligently.

One bad habit which many drivers have, is driving with one foot on the clutch pedal. Time after time, this results in just enough pressure being exerted to permit the clutch to slip a little with consequent unnecessary wear on the facings and bearings as well.

The same evil effect is produced by continually throwing the clutch out to slow the car down when driving in crowded traffic, then speeding up and slipping in clutch with the gear lever still in high.

Clutch operations should be deliberate and positive. The clutch should definitely be in or out. A clutch should not be used any more than is necessary to accomplish the definite functions for which it is designed.

First and foremost in the care of a clutch is its lubrication. The lubrication points vary with the type of clutch. Find out from the instruction book where, how and when your clutch should be lubricated and follow those instructions religiously.

Cone Clutches are faced with leather which must be kept free from oil and grease or the clutch will slip, however carefully applied. If oil or grease

should accidentally get on the clutch from lubrication of the clutch bearings or as a result of excess oil working out into the clutch, it can be removed by spraying with gasoline, giving it about twenty minuets for the gasoline to evaporate and then applying five or six drops of neats foot oil. A temporary remedy is to dust with talcum or fullers earth.

The clutch leather is kept soft and pliable by the use of neats foot oil, of which five or six drops should be applied every month. If the leather becomes dry and hard, the clutch will "grab", be the clutch applied ever so carefully and gradually.

If the clutch leather wears down until the retaining rivets project, the rivets can be driven down with a punch until they are again below the surface of the leather.

If, through neglect and unnecessary use, the leather surface becomes glazed, the clutch will slip just as if it were greasy. This can be remedied by fastening the clutch down in the "Out" position, cleaning the leather with kerosene and then roughening the leather with a fine rasp, a key-hole saw or any other tool with which the result can be accomplished, after which a few drops of neats foot oil should be applied.

About the only care required by dry plate clutches is cleaning, which should be done once or twice a season to prevent or cure slipping which, generally, is due to accumulated dirt and grease. To clean, squirt five or six ounces of kerosene over the plate. With the motor running and the gear in neutral, move the clutch pedal back and forth quickly thus flushing the entire interior, washing the facings and discs,

afterward removing bottom drain plug and permitting the kerosene to completely drain out. If soon after cleaning, the clutch begins to slip, it may be due to oil leaking from the crank case or it may indicate the need of some adjustment. In either case, it should be looked after at once. Slipping, particularly if dry, will cause the plate to heat and warp.

A disc clutch running in oil, should be cleaned once or twice a season or oftener if it seems to either grip or slip. To do this, follow the same procedure as to clean a dry plate clutch except that, before washing, the old oil should be drained out. It will be necessary to use a pint or more of kerosene. After running the engine a little while, with the gears in neutral, moving the clutch pedal back and forth, drain, add kerosene again and after a few minutes flushing, remove and refill to proper level with new oil. If clutch should not seem to function properly, after cleaning, some adjustment is necessary.

Never adjust a clutch of any type until you are sure that an adjustment is really needed. Most clutch troubles are relieved or cured by cleaning and lubrication. If the trouble should persist after this is done, consult your instruction book which will probably tell you how to make the adjustment that seems to be required.

It must be remembered, too, that seeming clutch troubles may be outside the clutch. Sometimes, when a clutch fails to engage or disengage, as it should, the trouble is not in the clutch but in the connecting rods or levers or due to wear in the clutch collar or other points.

CHAPTER XVII

THE CARE OF THE BRAKES

If a car-owner neglects to make it an unfailing practice to regularly inspect his entire brake system, lubricating and making any adjustments or repairs which may be necessary, his carelessness is hardly short of criminal.

No other part of the car performs functions so vital to the safety, not only of the driver and those with him, but to pedestrians and other moving traffic as well. The ability of the brakes to hold—to stop the car—will in innumerable instances, mean the difference between safety and an accident with more or less serious results.

Inspections should be made at least once every month. All hinges, cams, toggles and lever bearings of every nature should be examined for looseness and for lost nuts, bolts and pins. At the same time, every bearing should be lubricated as provided by the manufacturer and with the lubricant specified. Many of these lubrication points, as the car owner will note from his instruction book, should not be left to a once-a-month lubrication but should be furnished with a wear-preventing film of oil at more frequent intervals.

The braking pressure on each wheel should be equal. Make it a point, every now and then, on coming in from a run to put the hand on the brake drums. If either or both are hot, you need no better

indication that one or both the brakes are dragging. This condition should be remedied at once. A dragging brake not only soon wears out the brake lining but also wears out the tire on that wheel, as well. A dragging brake will take hold quicker than the brake on the other side, probably causing its wheel to slide and grinding the tread off the tire. Tire companies allow no adjustment on tires which show evidence of such wear.

The braking pressure can be tested by jacking up the rear of the car, applying the brake and then observing if it is equally hard to turn each of the wheels. The pressure should of course, be the same on both wheels. In making this test try the pressure, as suggested, of the emergency brake as well as the foot or service brake by testing each in turn.

Adjustments to increase or lessen the pressure of the brakes on any car are given in the instruction book published by the manufacturer of the car. The car owner, however, should not be too quick to attempt to remedy any tightness or looseness by making the adjustment indicated. A brake that seems to slip may be caused by the brake band being covered with oil or grease or it may have become glazed with use or it may even be worn out. The rear wheels should be removed about once a month and the brake bands examined and cleaned with gasoline. Grease frequently works out of the rear axle housing or the differential and finds its way to the brake bands, which is certainly one place on a car which should not be lubricated. When the oil or grease has been

removed with gasoline the surface of the band may be roughened up with a file or other abrasive tool.

When a brake lining becomes worn, don't hesitate to have it replaced with a new one. A band that is worn down to where the retaining rivets are coming in contact with the brake drum should be removed and replaced at once. Not only will such contact fail to give the proper braking pressure but the drum itself will be unnecessarily injured.

Get a good lining. You can buy a cheap one but considering what it has to do, how important the part it plays in protecting you and your car and other people from accident by stopping your car when you want to stop it, why take a chance by buying any other than a well known standard brand.

Loose brake rods and connections cause most of the "clatters" heard about a car. Dirty brake bands cause many an attention-compelling squeak. None of them will be heard on the car of the car owner who gives proper attention to his brakes nor will he ever be the direct cause of one of those distressingly frequent accidents reported as being "due to defective brakes."

CHAPTER XVIII

THE CARE OF THE TRANSMISSION

The care of the transmission begins with care in the use of the gear shift levers. Worn or broken gear teeth or stripped gears are most frequently due to abuse—through improper gear shifting. The expensive repairs of replacements which these entail would not have been necessary if the car owner had handled his gears in a proper manner.

Whenever a car owner hears—on his car or another's—noisy clashing, slap-dash gear changes, he may be sure that the noise will be echoed, sooner or later, by the ringing of the repair man's cash register.

If he is careful in his gear changes, the car owner need not greatly concern himself with his transmission beyond seeing that it is occasionally cleaned and that it is always properly lubricated.

Every two or three thousand miles the cover should be removed and the old oil drained out or the old grease removed. Then the plug should be closed and the case filled about half full of kerosene and the engine run slowly a little while with the gears in neutral. Then drain out the kerosene and go over the gears with a stiff brush dipped in kerosene, looking everywhere on gears and in the case for loose particles of metal and observing for broken or burred teeth. If the wear on the gears has not been excessive, the car owner can smooth them with a file. If the

breaks or burrs are of any considerable consequence, he will certainly prefer to let some competent mechanic do the smoothing. Examination should also be made for loose bearings, particularly for end-play. This may be discovered by taking hold of the universal joint and trying to move it back and forth. If end play is discovered it should be corrected at once as stripped gears are likely to result.

Positively too much care can not be taken to prevent loose nuts or any other objects of any size or nature to get into the transmission case while the lid is off. Heap big trouble is sure to result.

After cleaning and inspection, replace the drain plug and refill to proper level with oil or grease as specified by the car manufacturer.

On old cars where the gears have become worn and consequently noisy, unscrupulous second-hand car dealers sometimes fill the transmission case with a very heavy grease which has been mixed with ground cork or similar material. This deadens the noise and fills up the inequalities so that temporarily everything fits tightly and operates with reasonable quietness.

CHAPTER XIX

CARE OF THE REAR AXLE, DIFFERENTIAL AND OTHER PARTS OF THE REAR END ASSEMBLY.

No part of the car is subjected to heavier or more continuous strain and wear than are the various bearings and gears of the rear axle and differential. In recognition of this, every manufacturer, in designing his rear end assembly has worked for simplicity and strength, endeavoring to have the smallest possible number of moving parts and these as strong and wear resisting as possible.

As a result, instances of breakage in ordinary use are rare and if proper attention is paid to lubrication, wear will be slow and even the adjustments will be few and of little consequence.

However, trouble—serious and probably expensive—will surely result if lubrication is neglected. The lubrication methods provided and the manufacturer's instructions as to when or how often to lubricate and the type of lubricant to use, vary with the different makes of cars. Whatever the instructions of any manufacturer are, they should be closely followed.

At all events, lubrication should not be at less frequent intervals than the manufacturer recommends. If the car is being subjected to particularly hard service or is being driven more miles per day than is usually the case, nothing but good will result if the

parts are lubricated even more frequently though, of course, more lubricant than is necessary should not be put in at any time.

The use of an excessive amount of lubricant is likely to result in oil or grease working out and onto the break linings. This will sometimes be the case even when only the proper amount has been used, although most manufacturers have more or less successfully endeavored to prevent it.

Trouble of this sort can be rather effectively prevented by winding the axle shaft for a space of about six inches with a strip of thin hard felt. Winding should begin from the wheel end and progress towards the differential. The felt can be fastened down with shellac and should be tied down with small strong string in several places. The edges of the felt should not lap. When the car is moving forward, the action will be to force the lubricant back towards the differential.

At least once every season—and surely before starting on a long tour—the axle and differential should be thoroughly flushed out with kerosene in order to remove any possible grit and small metal particles which may have worn off the gears. At the same time all gears and bearings should be examined for broken or worn surfaces. All inequalities should be remedied and cracked or worn balls or rollers replaced; after which the housing should, of course, be packed with new lubricant as specified by the manufacturer.

A noise eminating from the axle or differential should be cause for alarm and have immediate attention. A humming or grinding sound may mean

lack of lubrication. If this should not be the cause, some of the gears are worn, broken or some adjustment is needed. An intermittent click or grinding knock occurring now and then indicates that there is a broken tooth and the broken off part is catching in the gears. Any of these things demand immediate attention, "lest worse befall". Almost all of the instruction books tell the car owner how to make certain adjustments in the rear end gears but many adadvise the car owner to have any necessary work on these gears done by a competent mechanic, preferably at the service station maintained by the agent for the car. The latter is the best course to pursue unless the car owner has more confidence in his mechanical ability than is possessed by the average.

Other rear axle parts, which though hidden away under the car and consequently hard to get to, must never-the-less have more or less frequent attention, are the rear universal joint (or, on some cars, the pinion shaft bearing) the torque (arm, rod or tube) connections and the brake band supports, brake operating shafts, etc.

The universal joint is generally enclosed in a leather housing which should be-re-packed every 1,000 or 1,500 miles. If no housing is provided, one can be purchased and will pay the owner big dividends on the very small amount invested. When lubricating, inspection should also be made for loose or worn pin at the propeller shaft connection.

The rear axle connections of the torque arm, rod or tube, whichever are used, should be inspected about once every two months and all loose bolts tightened.

Looseness at this point (and sometimes at the forward connection) cause knocks which are very hard to locate. Lubrication at some of the torque connections is also necessary on some cars. Every car owner should be sure that he knows what is necessary on his car.

CHAPTER XX

THE ELECTRIC EQUIPMENT—ITS CARE

Furnishing as it does, the vital element essential to starting, ignition and lighting, the importance of a properly functioning system is obvious. It can be likened to the nerve system of the human body.

To the average car owner, the electric system of his car is a matter full of mystery. This need not be the case. From the automotive courses offered by the automobile schools and Y. M. C. A. or from the numerous books on the subject, to be found at any library, the car owner can gain an intimate acquaintanceship with his electrical equipment that will enable him to solve any electrical troubles which may arise to vex him.

But unless the car owner has, obtained a really thorough knowledge of this technical subject, he should take his electrical troubles to a service station maintained by the manufacturer of his car or by the manufacturer of the part in which the trouble exists.

The average car owner will do well to confine the attention he gives to his electrical system to caring for it as its necessities demand. If he does this, he will have done all that the manufacturer hoped for and about all that will be necessary to get from it efficient service.

To be able to do this, he should learn the type and make of his battery, magneto, generator, timer, starter

and the principles upon which each of these function.

Because of the limited space available it is impracticable to give, a detailed description of the various electric systems used in each make of automobile. All that will be attempted to give information—general in its nature and application—that will help the car owner to more wisely use and more intelligently care for his electrical system and thereby enable him to avoid most electrical troubles and remedy such minor troubles, as he, without a technical knowledge of the subject, may safely undertake.

Since more troubles arise through faulty distribution than through inefficient generation of the electric current let us first consider:

Electric Connections and Wiring.

The point to remember about electrical connection is that they must be clean and free from corrosion, moisture, grease or foreign matter of any kind that may serve to partially conduct the current and thus produce a short circuit and that they must be tight, so that perfect contact between the conducting surfaces will be continuously maintained. Let the car owner periodically inspect his connections, tightening, where any tendency to looseness is observed and scraping and polishing away any corrosion that may be found and he will have done all that should be necessary in regard to the electrical connections.

All wires must be kept clean. Grease and oil dissolves and will soon ruin the rubber composition with which wires are insulated.

Wires should be kept straight as possible. If bent sharply the wires likely, in time, break through the

interior insulation and cause a short circuit which may be hard to locate.

Wires should not come in contact with each other or with the frame or other parts of the car as chafing or induction will likely result. Where contact cannot be avoided the point of contact should be well wrapped with friction tape.

Since any defect in the insulation will permit a leakage of current and produce a short circuit, the car owner should watch for worn or chafed insulation and insulation that has become deadened, cracked or porous through age or action of grease.

Short Circuits—Broken Connections—How Evidenced How Detected—How Remedied.

The failure of any part of the lighting, starting or ignition systems to function properly—though sometimes due to other causes as well—is frequently, if not usually, due to a short circuit, loose or broken connection. For instance, a short circuit, loose or broken connection is frequently found to be the cause when:

(a) Engine will not start. (b) Engine hard to start. (c) Missing. (d) Engine stops suddenly. (e) Engine will not stop. (f) Lamps will not light. (g) Lamps flicker. (h) Lights are dim. (i) Lights dim when starter is used. (j) Lamps burn out frequently. (k) Fuses burn out frequently. (l) Generator fails to charge battery. (m) Battery discharges too quickly. (n) Ammeter does not register or registers inconsistently, that is, when ammeter indicates charge when it should indicate discharge and vice versa, or when it

registers charge or discharge when it should register zero.

Whenever any of these troubles arise, unless the car owner has well founded reasons for believing that the trouble is due to other causes, he should begin at the beginning—which is at the connection—and work over connections and wiring of the suspected circuit (see foot note) looking for looseness, dirt or corosion at the connections, chafed or broken insulation or breaks in the wiring.

Frequently these can be readily discovered by running the car at night or in a dark garage with the lights off, when the point where the current is leaking will be indicated by a bluish flicker or sparking, particularly when the wires or connections are moved.

A more thorough test can be made with a test lamp or with a volt meter, either of which can be procured, with full instructions for their use, from dealers in automobile accessories or electric supplies.

Another instrument for locating breaks or short circuits in the high tension wires is the recently invented Ignition guage which consists of a hard rubber insulating shell containing a glass tube filled with Neon Gas. On one end of the instrument is a metal cap. When this is brought in contact with a high tension current, the gas becomes luminous. This instrument which is about the size of an air guage, is said to be

If the trouble is in the ignition and seems to be confined to one certain cylinder or cylinders, it may be located in the high tension system between the timer or distributor and the spark plug of the missing cylinder or cylinders, though the spark plug or plugs may be at fault. Trouble occurring regularly or irregularly in all cylinders will most likely be located in the low tension system or in the secondary system between the battery and the timer or distributor.

very efficient. It is sold by accessory dealers.

If, in searching for the cause of his trouble, the car owner discovers losoe, dirty or corroded terminals or connections, the remedy is obvious. Small worn or broken places in the insulation can usually be repaired by coating with pure rubber cement, wrapping with tire tape when the cement has dried.

If the insulation has become dead, cracked or porous, permitting the leakage of current at numerous places the wires should be replaced. To mend a broken wire, scrape each end clean, wash with gasoline to remove any particles of insulating material and splice by wrapping the wire once around each other, leaving about an inch of wire at each of the loose ends and then, with pliers, wrapping each of these ends firmly and smoothly around the wire. Then solder the splice and insulate by coating with pure rubber cement and wrapping well with tire tape.

The Lighting System.

Nearly every variety of lighting trouble is directly traceable to (a) Loose lighting fixtures. (b) Loose battery terminal. (c) Loose connections. (d) Broken wire. (e) Broken insulation causing continuous or intermittent short circuit. (f) Work battery. (g) Bulbs of incorrect voltage. Lighting troubles therefore should be easily found and quickly remedied.

Lamp bulbs will become black through use or some jar or shock may break a filament. When for any reason a bulb must be replaced the car owner should be careful to get a bulb of the correct voltage.

The lamps are frequently grounded in the headlight

rim which should therefore be kept pressed firmly in place.

Dirty lenses can be washed with soap and water and afterward dried with a soft cloth or chamois that is absolutely free from grit. Under no circumstances should the car owner attempt to clean mud or dirt from his lenses with a newspaper or dry cloth.

If accumulated dust on the reflector can not be removed by blowing, it may be removed and the reflector polished by rubbing it with a soft, new, perfectly clean chamois and a little rouge moistened with a few drops of alcohol. Use as little pressure as possible, beginning at the outer edge and rubbing toward the center with a spiral motion, afterward rubbing with the dry end of the chamois in the same manner.

To focus the lamps, bring the car a hundred feet or so from a wall and then, one lamp at a time, turn the adjustment screw until there are no rings or dark spots in the beam of either lamp. Then take the car out on the road and adjust the lamp supporters so that the beams converge and strike the road about one hundred and fifty feet ahead of the car.

Ignition System:

Since all that the average car owner can safely do to or for his ignition system is to give it proper care, no attempt will be made to describe or define the different systems or all the points in which one system differs from another.

The big point of difference in ignition systems is that in some, the ignition current is generated by a magneto while in others it comes from a battery, dry cell or storage.

All systems are alike in that the ignition current,

whatever its source, is conducted from its point of origin, through a timer or distributor and thence to the spark plugs, from the points of which the inigtion spark is delivered into the combustion chambers of the cylinders.

The car owner should find from his instruction book what sort of system his car has.

Magneto Ignition:

If his car has magneto ignition of any make, the following is about all he can and should attempt to do in order to preserve its efficiency: (1) Keep the magneto clean externally and internally, being careful not to disturb its adjustment in any way; (2) Keep the interior of the breaker housing clean by wiping out occasionally with a cloth dampened with gasoline; (3) Remove accumulation of carbon, dust or oil on the interruptor with a tooth brush dipped in gasoline; (4) About once a season it may become necessary to smooth the interruptor points with a fine jewelers file; (5) Religiously follow manufacturers instructions as to lubrication. They generally tell the car owner to put four or five drops of good light oil (not engine oil(in oil the cups every thousand miles and a single drop of oil on the pivot of the interuptor lever every hundred miles, using a tooth pick for the purpose and being careful not to get any oil on the contact points as it will cause burning and pitting; (6) Aside from such necessary care, lay off the magneto and all its component parts. Don't monkey with it or adjust it and above all, do not attempt to repair it.

For cleaning any part of the electrical units use GASOLINE rather than kerosene because gasoline

leaves a dry surface but when using it the ignition switch should be "off" and one of the battery cables disconnected from the battery terminal, the end wound with friction tape and left off until the job is finished. Otherwise a spark and a fire may result.

Vibrator Spark Coils: If these form a part of his ignition system, about all the car owner can do is to clean or smooth the contact parts when necessary. To do this use a fine flat jewelers file between the stationary and movable points. The distance between these points should not be more than 1-32 of an inch. If they should get out of adjustment, tighten or untighten the adjustment screw until right distance is established.

Battery Ignition: If his car is equipped with battery ignition (as non vibrator coil system) his first interest will be in the battery—dry cell or storage—from which the ignition current is drawn. For detailed information regarding batteries and how to care for them, refer to chapter X.

Points for Care in All Ignition Systems:

As stated in the beginning, all ignition systems are alike in that the ignition current must be conducted from its point of origin through a timer or distributor and thence to the spark plugs from the points of which the ignition spark is delivered into the combustion chambers of the cylinders.

Consequently whatever sort of system he has, the car owner will want to give all necessary attention to his ignition wiring and connections, his timer or distributor and his spark plugs.

Wiring and Connections: What is said in the begin-

ning of this chapter regarding wiring and connection applies particularly to the ignition system.

The Timer or Distributor: The Ford timer differs importantly from the timers or distributors used in other cars. A special chapter has been devoted to it. See chapter XI, page 98.

For timers or distributors of other makes, the important points to note are, that, they are clean externally and internally, free from excess oil, carbon, dirt and moisture.

The track traveled by the rotor brush should be wiped occasionally with a clean rag moistened with gasoline and when clean, the track should be given a very thin coating of vaseline. If the segments become rough, smooth them with fine emery paper, being sure that no dust remains on the rotor track.

Rarely, if ever, should it be necessary to increase the tension of the little spring which regulates the pressure of the rotor brush against its track. It is bad practice to stretch this spring out and increase the tension with an idea of securing better contact. The contact is usually good enough. Too much will cause excessive wear and create friction which will burn the parts affected.

If the distributor is kept clean and dry and lubricated as required, little trouble will be experienced with it.

Spark Plugs.

Terminals should be examined frequently. Keep them clean, tight and dry.

Inasmuch as the cause of misfiring, etc., is most frequently located in the spark plugs, it is important that these be inspected at least once a month for carbon, adjustment of points and cracked porcelains. Af-

ter the plug has been removed, if it can be disassembled, the porcelain can be taken off and the carbon removed with gasoline on a cloth or stiff tooth brush. The points may be polished with a piece of fine emery cloth. In reassembling see that all parts are perfectly dry. The gaps between the points should be inspected as long wear may cause them to become so wide that the spark will not pass under compression, even though it may do so in the open air. For battery ignition, the gap should be about equal to the thickness of a thin dime, much smaller if magneto ignition is used. Specifically, for coil ignition the gap should be 1-32 of an inch; for magneto ignition, 1-64 of an inch.

A defective spark plug may sometimes be the cause of some trouble which has been attributed to something else. A crack in the porcelain which will unfit the plug for service may be too small for detection even when suspected. For this reason it will be well to test the plugs before removing them to be cleaned. This may be done by opening the relief cocks, one at a time, with the engine running. If any cylinder regularly produces a hiss but no flame, the plug may be suspected but not yet condemned inasmuch as a lack of ignition may be due to other causes. Take the plug out, clean it and if no defect can be found, polish the points and spread them about 1-8 of an inch apart. Attach the wire, start the engine and see if a good spark jumps from point to point. If it does the plug itself is o.k. and after the proper adjustment of points is restored, it can be put back in service.

If the cylinder still fails to show flame, the trouble can be looked for elsewhere. If the plug does not show

a good spark, exchange positions with some other plug that is known to be o.k. If that plug shows a good spark, the first plug is surely defective. If, however, the second plug does not spark, the trouble should be sought elsewhere.

When it becomes necessary to buy another plug, be sure that it is the correct type and length. If the discarded plug was one of the set which came with the car, one can do no better than to buy one exactly like it

The Generator:

This is the name given in motoring parlance to the dynamo which converts part of the mechanical power of the engine into electric current which flowing into and charging the batteries is used, as needed, to light the lamps, turn over the starter and also, in some systems, to furnish the ignition current.

The generator is a self contained and independent except that in some systems the generator and the starter are built into one machine.

Ordinarily the generator will perform its functions without any particular care or attention from the car owner. About all the routine care that the generator requires is to keep it lubricated. About every thousand miles, a few drops of light or medium oil (as specified by the manufacturer) should be placed in the oil cups, observing to see that the oil ducts leading to the bearings are open and being careful to see that afterwards, the cups are closed to prevent entrance of dust, etc.

No other lubrication is required. The graphite in the brushes lubricates as well as conducts. Oil or grease on the commutator will practically ruin the conductivity of the brushes.

If, as infrequently happens, the generator should

cease to function properly, the fact will be revealed by the ammeter or indicator registering "discharge" or "neutral" when "charge" should be indicated, or by the battery discharging too quickly.

This, however, does not quite prove that the generator is at fault. Test it by holding a screw driver on the terminals. If a good spark is evident when the connection is broken, the generator is not at fault and the trouble will be found in the connections or wiring between the generator and the battery or between the battery and the ammeter.

If the trouble is in the generator, it will most likely be found in the brushes or their holders or in the commutator. In looking for trouble in the brushes or brush holders see (1) that the brushes are not so badly worn or that the springs have become so weak that the brushes are not making proper contact. In which case they should be replaced. See (2) if accumulated dirt is causing brushes to stick and if so, clean with gasoline, being sure to return each brush to the holder from which it was removed.

In looking for trouble in the commutator, see (1) if it is dull or dirty and, if so, clean by putting a little oil on a cloth and holding it against the commutator while it is running, being sure afterward to remove all of the remaining oil.

Any other commutator trouble had better be left to the experienced workman. Indeed, this advice might well apply to any work on any part of the generator or the cut out or current regulator, unless the car owner has well founded confidence in his own ability.

Starter:

Due alike to its inaccessible location and the nature

of its construction, there is little the car owner can do either in caring for, adjusting or repairing the starter. Indeed, there are few points where the care is needed and if any repairs or adjustments should ever be necessary, the car owner will hardly be competent to make them.

Care of the starter begins with its use and in this, the principal point to remember is that the starter pedal or button should be released the instant the engine picks up.

Sometimes the starting motor continues to run after the pedal or button is released, this indicates a weakness in the spring governing the return and about the only remedy is to replace it with a new one.

All terminals and switch connections should be kept clean and tight. No oil should ever be permitted to get on the blades of the contact switch. The starter should be lubricated as specified by the manufacturer.

Starting troubles are usually located elsewhere than in the starter. For instance, if the starting motor will not run, the trouble is most likely due to a very weak battery, to bad battery connections, to a short circuit in the wiring or to bad contact between the fixed contacts and the blades of the starting switch. If the trouble is the last named, the blades can be sprung further apart. The remedy for the other causes named is obvious.

If the seat of the trouble is not found in any of the above possible causes the car owner can reluctantly conclude that something is wrong with the starter itself and he should ask his service station to remedy it.

CHAPTER XXI

WHAT A MOTORIST SHOULD KNOW ABOUT THE BEARINGS IN HIS CAR

By H. T. Dieterich, Bearings Service Co.

Manufacturers appreciating the necessity for constant and proper functioning of anti-friction bearings have so engineered and designed these units that when when given proper care, they will last the full life of the car. However, being for the most part hidden in the mechanism, bearings are often never seen by the average owner and as a general rule, he does not give them the attention and care that he should.

Lack of lubrication is really the cause of the vast majority of bearing failures. The motorist should make sure when his new car is delivered to him that the bearings have all been supplied with lubricant. He should also see that there is a clear passageway from the grease and oil cups to the bearings and at regular intervals afterwards, exercise good common sense in making sure that these important parts are at all times properly lubricated. It is well to remember that grease is cheaper than metal.

Only the purest mineral oils and greases should be used in lubricating anti-friction bearings. When bearings are enclosed and operating at high speed under small loads a light oil may be used; in other installations, a good light grease or medium grease is more satisfactory. Avoid carelessness in cleaning the bearings

for inspection after removal. If dirty gasoline or kerosene is used the grit and dirt is usually washed into, rather than out of, the bearing. One of the most efficient methods of cleaning bearings is to dip them in a pail of boiling water containing a cup full of washing soda. This solution will cut the grease and oil and remove any grit or dirt that may be present. If the bearing is to be used again, it should be dipped in kerosene immediately after the removal from the washing fluid. This will remove the cleaning solution. It should then be packed in grease.

If a bearing is correctly mounted, kept in alignment, free from grit and dirt, and well lubricated, it will always give satisfactory service. If a car has had a severe shock of some sort—say from an accident—later trouble can be prevented by having the bearings inspected to make sure that they have not been injured in any way. Frequently, bearings are ruined by carelessness on the part of mechanics in removing them. In removing the races of press fit bearings a puller should be used, if available. The force of the puller should be directed against the sticking races. If prying or driving is necessary, care should be taken that the force is not applied direct to the free race and transmitted thus thru the balls or rollers to the sticking race. If driving is necessary a piece of wood or brass should be used in conjunction with a babbit hammer or mallet so that the blows, while sufficient to loosen the race, will not be hard enough to cause possible injury to any part.

Instructions on the care necessary to remove a bearing should similarly apply when it is to be replaced. Bearing outer races are usually press fit in the housings. The inner races are, in general, a light drive fit

on the shaft. The pressure necessary to replace the bearing should, as when removing, be applied directly to the sticking race. In replacing the inner race of a bearing consisting of two or more parts as in the case of Timken and Hyatt Bearings or a bearing of a single unit type, such as manufactured by the New Departure Manufacturing Company, a piece of tubing just large enough to fit over the shaft and fasten against the inner race is a practical tool to use. In forcing the bearing into position with this tool, the pressure is applied in such a way as to distribute the force equally over the race thus preventing a tendency to wedge. The condition of the bearing housing and shaft is a matter which should be watched carefully when replacing bearings. The housing if worn will allow the bearing to fit loosely and play will be noticeable. If this condition exists, a new housing should be secured or possibly the old housing may be bushed. Shims, however, should never be used. The inner race being generally a light press fit on the shaft if too tight and forced, might throw the whole bearing out of alignment thus causing it to burn In a case of this kind, the shaft should be turned down; never grind down or narrow the outer circumference of a bearing in an attempt to make it fit the housing or shaft. Annular ball bearings cannot be adjusted, this naturally means that if such a bearing is worn, it should be replaced with a new one. At first thot, it might seem as tho annular ball bearing equipment is consequently expensive to maintain. However, this is not true, as a bearing of this type will give unlimited service if properly installed and cared for.

Hyatt bearings are not adjustable and when wear

occurs the worn parts must be replaced. A complete Hyatt bearing may be one or a combination of two or three parts. For example, a roller assembly and an inner race may in some cases, constitute a complete Hyatt bearing of a given number; or a roller assembly and an outer race may be a complete bearing. Some Hyatt bearings however, consist of all three parts, i. e. inner race, roller assembly and outer race, again in other cases, the roller assembly only may be used, the shaft and housing taking the place of the inner and outer races respectively. It is not always necessary to replace a Hyatt bearing completely where only one of the parts is found to be worn. A new inner race, for example, may be used with the old roller assembly, provided of course the latter is in good condition. Examination should show whether the surface of the races and rollers are smooth and in good condition. Particular attention should be given to the cage which contains the rollers and keeps them in alignment. The cage should be rigid and if found to be racked or out of shape in any way, the entire roller assembly should be replaced with a new one.

When reinstalling, care should be used not to squeeze the cage as it is essential that the cage containing the rollers rotate freely which is not possible when it is jammed. Care should also be taken to see that the set-screw, which is used on some Hyatt bearings, does not project thru the race thus interfering with the operation of the rollers. Timken bearing on the other hand, are adjustable and the following method should be practiced when adjusting them. After packing the bearing with grease, screw the cone and roller assembly on the shaft tightly against the cup or race being careful,

however, not to exert too much pressure. The pressure should only be sufficient to cause the bearing to bind slightly and the shaft or wheel should be rotated to see that it does not stick at any point. The cone and roller assembly should then be backed off so that the shaft or wheel turns freely but not enough to cause any perceptible end play. The locking device should then be secured without disturbing the adjustment.

A point to be considered when replacing inner front wheel bearings is the careful installation of the dust ring which should be backed solidly on the spindle. Care should also be given to the installation of the cup in the housing. The cup must be seated firmly and the exactness of the seating checked by measuring the distance all the way around, from the edge of the cup to the lip of the housing. These distances should be equal. otherwise the cup will not be squarely seated and will be out of alignment with the cone and roller assembly.

There are in the main, three classes of bearing installation. The first includes bearings on the fan shaft, clutch, starting motor, steering gear, etc., but these need not be considered because at these points bearings are not usually put to any severe test and the initial cost and convenience of installation become the determining factors. The second class includes transmissions, pinion shafts or worms, and differentials where extremely important shafts and gears are supported by anti-friction units. Even slight wear in the bearings at these points unless corrected, allows the shaft to drop out of true alignment and thus throws the gears out of perfect mesh. A loss of power and excessive wear of the gears inevitably follows the use of inferior or worn bearings at these points. The third class includes the

wheel hubs, where the bearings have to work under the tremendous pressure of the car's weight and are subjected to every shock and all vibrations resulting from traveling over rough roads. Bearings not properly maintained at wheel hubs, pinions and worms, will soon show the evil effects of carelessness on the part of the mechanic or motorist. This is also true with transmission and differential bearings, altho to a less extent. These evil effects will not be apparent alone in the bearings themselves but will also show up in the performance of the gears, the accurate adjustment of which may be destroyed.

The big factor in the satisfactory performance of bearings in a car is the human element. That of course means the person driving the car. It is a fact that a driver can ruin the gears of his car thru failure to drive with a minimum amount of gear clashing and in analyzing the causes of bearing failure the driver of a car or truck should give this point careful consideration. In sliding gears, especially when operated by an inexperienced person, there is a constant clashing when changing gears which often chips off particles of metal of the gear teeth. These small pieces of metal fall into the lubricant, are churned around and oft times find their way into the bearing ball races or retainers. Thus bearing failure is inevitable. Motorists should realize that a thoro cleaning out of the transmission case to remove the grease that may contain many minute metal particles and the replenishing with clean fresh lubricant is necessary to proper bearing performance.

The differential housing also needs like attention. Hubs seldom give trouble, and as a result they are generally inspected only about once a year, when more fre-

quent inspection would prove worth while especially when the car is in constant hard service. The felt packings at the hubs, especially those in the front wheels, wear out, road grit and water finding its way into the hub interior. Inspect and oil the bearings in your car occasionally even tho they do not complain of neglect by groaning and squeaking.

CHAPTER XXII

CARE OF THE STEERING GEAR

One of the parts of the car most frequently neglected is the steering mechanism. Many car owners do not realize how continuous is the motion of the gears or how great the strain imposed during every minute the car is in motion and consequently pay little attention, if any, to their steering gear unless play or back-lash becomes so excessive as to absolutely demand attention and adjustment.

If early wear and consequent repair bills—to say nothing of danger through accident—is to be avoided, the steering mechanism should be occasionally inspected, kept in proper adjustment and its gears and bearings lubricated freely and frequently.

The lubrication points and methods provided for lubrication vary with the different makes of cars and the different types of steering apparatus but it may be taken as a rule, here as elsewhere, that every moving part should be kept covered with a wear-preventing film of oil. And, do not be too economical in the amount of lubricant applied. Inasmuch as there is no pumping action in these gears, the lubricant must be packed in and kept packed in. Follow the specifications of the manufacturer as to the lubricant to use but you will make no great mistake if you lubricate your steering gear twice as often as he recommends.

Ordinarily a long period of service will elapse be-

fore the steering gear will require any adjustment and the need of adjustment will generally be made apparent by lost motion or excessive play in the steering wheel. The amount of play that is allowed will depend somewhat on the preference of the driver. Some play is desirable but too much makes dangerous steering. When the play amounts to as much as two inches it should be adjusted.

To do this, jack up the front wheels, manipulate the steering wheel, testing and observing at each connection or bearing. The method of adjustment will vary with the type of steering apparatus and will be described in detail in the Instruction book issued by the manufacturer of the car. Where the wear has been so excessive as to require new bushings, while the car owner can put these in, he will usually prefer to have them inserted by a mechanic.

The car owner should be sure, before making any adjustment, that the fault is really in the steering mechanism. Lost motion which may be attributed to some part of the steering mechanism, is sometimes due to a "wobble" or looseness in the front wheels.

To test for this, first drive a block of wood between the knuckle and the axle and then test the wheel for looseness by taking hold of it at top and bottom or at each side and endeavoring to move it from side to side. If there is no looseness, the fault is in the knuckle pin and its bushings which probably call for new bushings. If looseness is apparent, the trouble is probably in the wheel bearings.

CHAPTER XXIII

THE CARE OF THE SPRINGS

Trouble of various kinds and various degrees of seriousness may result from lack of attention to the springs and to the bolts, clips and fastenings by which these are attached to the axles.

At least once a week, the bolts should be examined and, if a tendency to looseness is observed, tightened. Loose spring clips may not only cause the wheels to get out of alignment but are also the principal cause of broken springs.

Moisture must be prevented from getting between the leaves. Moisture will invaribly cause rust and rusty springs cannot move upon each other as they must if they are to afford the resiliency and riding comfort for which they were provided. Keep moisture out by frequent (some manufacturers say, daily) lubrication of the leaves.

On some cars this is provided for by oil cups or some sort of arrangement to draw the oil between the leaves by capillary attraction. If no such means are provided, it can be accomplished to a large degree, at least, by squirting oil on the edges of the leaves, or better still, the car can be jacked up (not the wheels) until the pressure is off the springs, and the

leaves pried apart with a screw driver and graphite grease forced well between them.

On weekly inspection for loose bolts and clips, look also for cracked leaves. If rust has been permitted to accumulate between the leaves, the spring becomes for all practical purposes, as if they were solid pieces. They should be taken apart, sandpapered thoroughly and well covered with graphite grease.

New cars sometimes come from the factory with the holes in the grease cups provided for the spring shackle bolts clogged up with enamel. On buying a new car an examination should be made to see if this is the case and the holes opened up so that the grease can get out.

If the car owner pays proper attention to his springs, he will not only eliminate the most common cause for squeaks but will also be able to point out, after long service, that "she rides just like a new car."

CHAPTER XXIV

THE CARE OF TIRES—HOW TO GET MOST MILEAGE

Tire expense amounts to about one-third of the total expense of running an automobile—the other two-thirds being about equally divided between gas, oil, maintenance and depreciation of the car itself.

Usually a car-owner knows that a certain degree of fuel economy can be achieved by proper adjustments and careful driving; many car owners realize that careful driving and intelligent care of the car will very greatly reduce the cost of maintenance and depreciation, but very few give any real thought to their tires or realize how this large part of their total operation expense can be reduced.

Tire economy begins with tire selection. Many a car owner who would not consider buying other than standard supplies for his office, store or factory will fall for the "reduced prices" and "special discounts" and the trick guarantee of the dealer in "gyp" or unknown brands of tires.

To do this is to speculate with the smallest possible chances of success—to gamble with "all odds in favor of the house."

Here is a basic fact. A dollar will buy just so much in tire building material and go just so far in paying tire builders' wages. Can any thinking man

imagine that the manufacturer of the "gyp" tire has any buying advantage or knows any manufacturing short cuts that would enable him to turn out a quality tire for less money than the reputable tire manufacturers?

Do not be deceived! The price of the "gyp" tire indicates that the quality has been cut by the use of cheap fabric and poor quality rubber loaded with adulterants—made by unskilled labor without inspection for hidden imperfections and weaknesses. Or, as often the case, such tires are made from old carcasses collected from junk dealers, re-lined, covered with a fine looking tread, painted up and sold for new tires at a "startling reduction."

The reputable tire manufacturers spend thousands of dollars on inspection of materials and finished goods to assure the car owner of dependable merchandise.

A "guarantee" is not always a guaranty. It is seldom that big value can be bought at a "big discount." Real value is seldom advertised in red ink. The bigger the "gyp" guarantee, the bigger—and sooner—the blow out.

"Seconds" mean nothing more than second class, or more often, "no class." If the manufacturer is not willing to take a chance on the service such a tire will give, why should the car owner?

Economy in tire buying does not come from looking at the price tag but at the name over the dealer's door, and the name of the manufacturer. If the dealer is well annd favorably known—if the manufacturer is of well-known standing and responsibility —then and then only the car owner is assured of full

tire value, dependable service and sure protection against possible defects.

But no tire, however well or honestly made, is abuse-proof. It is a common saying among the trade that car owners generally get just about one-half the mileage out of tires that the manufacturers build into them. The car owner generally ruins the tire with carelessness or abuse and then blames the manufacturer.

Nearly every tire of standard make, unless driven in country where the roads are exceptionally bad, will far outrun its mileage adjustment basis if given proper attention.

Tire mileage will be big and tire troubles will be few if the following suggestions are heeded.

Use care in applying your tires. First see that the rim is cleaned and all rust, dirt and foreign matter is removed. Watch the sides of the rim—see that they do not remain flattened due to constant pounding on the road. Your dealer can tell you where to have them straightened out. Be sure to use a flap in all but clincher tires and so prevent tube pinching.

Keep tires inflated. Buy a tire gauge. At frequent intervals test the pressure of each tire, even if it does SEEM properly rounded out. The pressure should not be less than fifteen pounds per square inch of tire section—more if the car is carrying a load, which at this pressure causes the tire to flatten appreciably. Running a tire under-inflated will cause internal friction and heat which will soon cause the layers of fabric to separate. Furthermore, a fully inflated tire presents a smaller wearing surface to the

road and is less susceptible to punctures and road wear.

Cuts in side wall or tread should be repaired at once. It is a good plan to frequently look for these when the car is brought in. If neglected they admit water and sand which under pressure with continued use, will cause the cut to increase in size—sand blisters will form and the tread comes loose for a considerable distance. Stop cuts as quickly as they are discovered. Small cuts can be cured with tire dough, cure cut, or any of the similar preparations put up for this purpose by tire manufacturers. Larger cuts should be repaired by a competent vulcanizer. Attention to tread and sidewall cuts can easily result in one-third longer life to the tire.

Avoid Tire Fillers, Reliners and Puncture Proof Contrivances. So far there has never been a substitute developed to replace the air used in a pneumatic automobile tire, although a number of tire fillers, puncture proof tubes, reliners and such are on the market. The use of these parts does just one thing—shorten the life of your tires due to increased weight, also through the additional heat annd friction developed by the constant flexing of the carcass from road contact. Furthermore, all tire manufacturers waive their guarantee when substitutes for air are used in their tires. So why take chances?

Don't allow oil, grease or acid to remain on the tires. If road contact with any of these is unavoidable, wash the tires as soon as possible with soap and water. Grease is the natural enemy of rubber. If it is left on the tires, damage will surely result. For

the same reason be sure the car does not stand on a greasy garage floor.

In putting in tubes always see that the inside of the casing is free from sand or other foreign matter, dust tube and inside of casing freely with powdered mica and see that the flap is smoothly adjusted. Do not carry spare tubes in boxes as shipped by the manufacturers, for the action of the car will chafe them. Secure a tube bag from your dealer—they are made for this purpose.

Change position of tires frequently. Rear tires wear more rapidly than front tires. Wear can be equalized by occasionally exchanging positions of all tires.

Keep spare tires covered. Tires do not deteriorate from age as rapidly as from exposure to light, moisture and varying degrees of temperature. The amount of protection afforded by tire covers make it real economy to use them. If tires are stored, keep them in a cool, dry, dark place.

Look out for bent fenders or projecting fender bolts. Sometimes in going over a bump or when the car is heavily loaded, these will cut and gouge the tread, inflicting serious damage.

Use "Over-size Tires." This will mean a larger volume of air between the car and the road, thus giving greater protection against vibration and consequently more riding comfort.

Be sure the wheels are properly aligned. Otherwise the tire will have a sidewise drag that will soon grind off the tread.

Keep the brakes equalized. If one brake grips harder and quicker than the other, that wheel will

have to do most of the work in stopping the car and the wheel will slide with obvious results to the tire.

Keep out of the car tracks. Otherwise excessive wear of the thinner side-wall of the tire will result. Furthermore, iron splinters on the rail edges, sharp switch points, frogs, etc., may cause serious cuts. There is also the danger of skidding on wet rails.

Wild-west stops," approaching the stopping place at speed and then stopping the car with a sudden application of the brakes and consequent sliding of the wheels is something no tire was made to stand.

Avoid spinning the wheels in mud or sand. A few minutes of this can cause more wear than miles of ordinary use.

Use chains only when absolutely necessary and be sure they are properly applied. Be sure the rounded side of the links lay smooth on the tire and that the chain does not fit sngly, otherwise damage will result.

Keep away from the curb. The result of driving along-side the curb so closely as to grind the tires against the concrete is too obvious to require description.

Do not run on a flat tire. Running "flat" is very expensive mileage for even a short distance. Better run on the rim at slow speed, or better still, carry one or even two inflated spares for use when needed. Do not let the car stand on a flat tire over night.

Tire troubles on the road can be lessened by carrying at least one good inside blow out patch, a cold patch tube repair kit, a can of tire putty or cure cut, a tube of rubber cement, a can of mica and a box of valve insides, as well as a spare tire and one or two extra tubes.

CHAPTER XXV

KEEPING THE CAR SPICK AND SPAN

Every car owner wants to preserve the original spick and span appearance of his car, either from a personal pride or a desire to maintain its re-sale value. It is seldom that a re-paint job has the "classy" look of the original finish and many a time a poor appearance has knocked several hundred dollars off the selling price of a car which otherwise was in excellent condition. Of course long exposure to sun and rain and wind and the washing necessary to remove the inevitable mud and dust will, in time, kill the lustre, but with care a car can be kept looking sleek and shiny for a long time.

Once a week the car should be given a thorough cleaning and polishing. This should begin with the top. A mohair top can be brushed. If it becomes discolored its appearance can be renewed by the use of some of the standard preparations sold for that purpose. An imitation leather top should be dusted off and can then be washed with clean tepid water to which a little castile soap has been added, after which it should be rinsed with clean water and dried with a soft chamois or clean cloth. The inside of the top can be brushed with a whisk broom or stiff clothes brush. In folding, care should be taken that the fabric is not pinched between any of the bows. A

folded top should always be protected with a dust cover.

Small breaks or ripped places in the lining of the top should be repaired as soon as noticed. Continued use will make the tear bigger.

If the curtains are lined with cloth, the fabric can be cleaned by thorough brushing with a stiff brush or whisk broom. Accumulated dirt and dust can be removed from the exterior with a damp cloth after which it can be cleaned more thoroughly by washing with a cloth and tepid water to which has been added a little mild soap. After drying thoroughly with a soft cloth, wipe with a cloth dampened with a very few drops of body polish. Where curtains can be carried rolled they should never be folded as repeated foldings along the same line will tend to break the fabric.

Leather or imitation leather upholstery can be cleaned with a cloth rung out of mildly soapy tepid water. If something stronger is needed to cut any grease add a few drops of ammonia, afterwards wiping off with cloth wrung out of clean water and drying thoroughly. Never use gasoline.

Cloth upholstery can be cleaned by thorough brushing and wiping off, afterwards, with cloth wrung out of tepid water to which a few drops of ammonia has been added. Grease spots can be removed by rubbing with cloth dampened with chloroform. The use of gasoline for this purpose will make a "circle" which is not the case when chloroform is used.

Seat covers add to the appearance of most cars and will pay for their cost in preserving the upholstery.

When dirty, they can be washed at home or sent to a cleaning establishment.

The secret in washing a car so that the original gloss will be preserved begins with the quantity of water used, rather than the pressure with which it is applied. A hose, of course, is best and the nozzle should be first removed. If the water is applied under pressure the force of the water dislodges particles of grit which, carried along with the water, grinds off the lustre with pretty much the same action as a sand-blast.

Do not wash the car any oftener than is necessary. When it must be washed, go over the whole car with the hose slowly, giving the water plenty of time to soak into and loosen the mud, wait fifteen or twenty minutes and go over it again when all the dirt—unless there is some mud which is greasy—will slip off. Greasy mud and also particles of asphalt or tar can be removed with a few drops of kerosene. Very little is needed and it should be removed as quickly as it has served its purpose.

After the mud is removed, if any grease spots remain, they can be removed with soap suds and a sponge or soft cloth. Use nothing but a mild soap and do not rub hard, and afterwards rinse with clean water.

After washing the car do not permit the water to dry on it as this will leave water spots. Go over the car and wipe dry with a very soft chamois or soft cloth which is free from lint. Whatever is used for this purpose be sure it is absolutely soft and clean and free from grit. Do not apply more pressure than can be avoided and do not rub with a circular motion

—follow straight lines always. After the car is thoroughly dry it can be gone over with a body polish if desired, of which there are many standard preparations on the market. In selecting a polish the owner should select one that is free from oil. It is practically impossible to wipe off all the oil content of an oily polish and that which remains will catch and retain dust and is likely to permanently injure the finish.

The under part of the car should not be neglected. Here pressure can be used to remove mud and as mud in that part is more likely to be greasy, it may be necessary to use a pail of soap suds and sponge.

Never allow water to get on the hood while it is hot as this will cause spots and probably also crack the finish. Also be very sure not to allow water to get inside the hood for obvious reasons.

Never allow mud to harden on the car as it will leave spots which will be slow in coming off and may also dull the lustre. Wash all the mud off the car as quickly as possible even if a more thorough cleaning is postponed.

Never use a feather duster to dust off the car as it only beats the dust into the finish and will also likely carry grit which will scratch the finish. For dusting a soft cloth with a few drops of body polish is best.

Touch the finish lightly. A varnished surface is not in any way like a brass lamp or any metal surface. Pressure is always harmful.

If it is necessary to wash the radiator wash with

the hose from the inside out—never from the outside in.

If caught in a rain storm sponge off the hood as soon as possible. Rain drops falling on a hot metal surface will make spots and dull the lustre if allowed to remain.

Many good polishes are on the market. If the car owner wants to make his own polish, one which is recommended by several authorities is as follows:

Turpentine	1 gal.
Parafine oil	1 pt.
Oil Citronella	3½ ozs.
Oil Cedar	1½ ozs.

This preparation, it is said, will remove grease, rain and mud spots. Before application the car must be thoroughly dry and it should be put on with a soft cloth and should be rubbed perfectly dry to prevent dust from collecting.

Body scratches or breaks in the enamel on any part which exposes the metal should be filled in with paint or enamel as soon as possible.

Nickel plated parts can be cleaned with any good silver polish. For cleaning and polishing brass many standard preparations are obtainable. Aluminum can be brightened by washing with a solution of hyposulphate of soda, which should afterward be washed off. A mixture of equal parts of soapy water and wood alcohol will effectively clean windows. Tissue paper is best for polishing them afterward.

Windshields can be kept clear in rainy or snowy weather by washing them in a solution containing two ounces of water, two drams of table salt and four

ounces of glycerin. Apply from the top to the bottom in straight lines.

Every time the car owner goes over his car it should be the occasion for a search everywhere for loose bolts, nuts, washers and pins. Continued looseness will not only mean excessive wear but also likely result in the loss of some part that will cause an expensive repair later on, if not immediately and probably serious trouble.

Furthermore, looseness, even when unlikely to result in immediate or ultimate damage, will, at all events, cause rattles and squeaks which no car owner wants. Squeaky door hinges can be cured by lubrication with a mixture of dry graphite and oil. The same mixture can also be used with good effect on the hood lacings. Loose doors can be remedied by making small buffers of "tire dough" or "Cure cut" used for repairing cuts in tires.

Loose fender bolts cause many a rattle for which the remedy is obvious. Furthermore, a loose fender bolt is an invitation for fender-breaks which will get worse and worse unless they are immediately welded.

Many a car owner has blamed the tire manufacturer for rim cut tires when it was the condition of the rim rather than a defect in the tire that caused the trouble. Through rust and wear the edge of the rim (particularly the clinches type) may assume a knife like sharpness and the result is a "rim-cut" for which the tire manufacturer is in no way to blame. At least once each season the tires should be removed and all rust thoroughly removed with sand paper. If the edges have become sharp, as mentioned above, they should be rounded off with a file.

CHAPTER XXVI

TOPS AND UPHOLSTERY

How long to Prolong Their Life—How to Preserve or Renew Their Appearance—Hints on Replacement.

By A. H. Berwold, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Stand on any corner and study the cars that pass. What impresses you most? Is it not the unsightly appearance of the great majority of the collapsible tops that you see?

Can the attractiveness of these tops be restored? In some cases, yes, to a limited extent. In most cases replacement is the only remedy. Could these tops have been kept in better condition? We are sure of it.

In the first place it is only frank to say that no type of fabric yet produced entirely meets the severe requirements of service on a collapsible top. The great majority of automobile manufacturers and top makers have found the rubber type of top material the most satisfactory covering available, and as this material is in such general use we will assume that your top is made of it.

There is a wide-spread custom among careful car owners to keep their tops up permanently. We approve this as a splendid prevention of most of the ills that befall the collapsible top. The frequent raising and lowering of a top, even if done carefully, and the flexing

and chafing of the material when the top is folded will lessen the attractiveness and shorten the life of a top no matter what it is made of. Leaving the top up permanently keeps it unwrinkled and shapely. Many motorists find that the raised top is also a welcome protection from sun and dust.

Dust and mud should be sponged off your top frequently and the material wiped dry to prevent streaking. Once the dirt on your top becomes "set" you will find it most difficult to remove.

Gasoline, tar, grease and all forms of oil should be kept away from your top and removed promptly and thoroughly should they come in contact with it. Oil spots, and dissolves rubber very quickly.

When the top fabric becomes dull or discolored refinish with a good top renewer. This will restore the glossy black finish with very little labor or expense.

If the top sags, an expert top maker can restretch it for you. Don't try this yourself.

Roll or fold the curtains carefully after using. Store them in the top or under the seat without any weight upon them.

Flexible windows should be cleaned occasionally with a mild soap and water. When badly stained try any cleaning cream made for use on pyralin and celluloid.

Replace broken windows promptly. Nothing makes a car more unsightly than broken windows in the back or sides. The cost of new windows is slight considering the immense improvement they make.

When Your Car Needs a New Top—Go to a responsible top maker and have him use a standard grade of

Keep the car in the garage when not in use.

rubber top material made and guaranteed by a manufacturer whom you know to be reliable.

Pay for and insist on getting first quality material not "seconds." You can't afford to have the job done over again by trying to save a few dollars on it.

Double texture top fabrics are by far the most satisfactory. They have a veneer-like strength and are doubly waterproof because of the impervious adhesive used between the two plies of fabric. This keeps the water out even if the rubberized surface becomes cracked or checked.

Double texture fabrics stretch uniformly and keep their shape better so that the top maker can turn out a smarter top with them. The extra cost is not great.

Single texture material is entirely satisfactory for side curtains in which flexible windows are used. If glass windows are used, the double texture will give it better support.

Perhaps you would like to consider changing from a collapsible to a rigid top so as to make your car really distinctive and elegant. In that case you should ask your top maker about the Craftsman (California type) Top which is now so popular.

The Craftsman Top—This is the solid frame, permanent top that originated in California and is now made by good shops in all sections.

This type of top is built with a strong, rigid, wooden framework ironed into the body of the car. This framework is padded and covered with a heavy, weatherproof material in any color or color combination desired. The shape of the finished top conforms to the lines of the car.

In this top the back and side windows are of heavy

plate glass. The side enclosures are of sliding plate glass or fabric and glass combined. Jiffy curtains with flexible windows are sometimes provided in addition.

Such a top gives all the comfort and beauty of an enclosed model at only a fraction of the extra cost of the same. It converts a used car into one that the owner can drive with real pride or sell to exceptional advantage.

The Care of Upholstery—Open cars are upholstered in either leather or a leather-like material of the Fabrikoid type. With reasonable care either type will give you good service, and either type will suffer from abuse.

You must be more careful with leather, especially if it is colored, as leather is porous and likely to become soiled and spotted from dirty clothing, foreign matter and rain. Once soiled it is best to turn the cleaning over to an expert.

When working inside the car keep the upholstery covered. Many garages and repair shops make Fabrikoid slip covers to protect the cushions and door linings from being soiled while repairs are in progress.

Dull and shabby upholstery can be refinished with a good leather renovator, but get a good one and follow directions. The danger is in getting too much of the finish into the plaits of the upholstery, where it dries very slowly and may ruin clothing a long time after it is applied.

Don't tolerate torn and broken down cushions. Have them re-covered at any good trimming shop. The improvement will justify the expense.

CHAPTER XXVII

DIAGNOSING TROUBLES

When the doctor arrived, he immediately vaccinated the sufferer and administered a dose of epsom salts. No immediate change for the better being apparent, he pulled a tooth, inspected the lungs with a stethoscope, applied an ice pack to the head and ordered the patient to the seashore for a complete rest.

This is an exaggerated and wholly imaginary case. Of course no doctor would treat any patient in such an illogical fashion, but it rather aptly illustrates the procedure followed by some car-owners when their car, for some obscure reason, begins to "act up."

A car that is driven with proper consideration for its limitations and cared for with intelligent appreciation of its necessities will give its owner little trouble. Some trouble, however, seems inevitable and may be expected, sooner or later.

Forewarned should be fore-armed. The car owner should be prepared for trouble when it comes, with a knowledge of his car and of "what makes it go." He should have learned from his instruction book or some other authoritative source the name of each essential part, where it is located, the function it performs, the principle on which it operates and the causes of each of the actuating impulses which combine to move the car.

If he lacks this knowledge, he had better leave his

ailing car alone. Uncalled for adjustments and unnecessary tampering can easily aggravate the original trouble or create troubles which had not previously existed. If a car owner does not know why he tightens this or loosens that or what will be the result of any adjustment he is about to make, he had better stay his hand or at least be sure of his ability to put things back the way he found them if his guess-work adjustment fails to accomplish the desired result. An automobile is a piece of machinery too fine and too expensive to be endangered by a bungling workman—whether it be the owner or an incompetent mechanic.

Possessing this knowledge, he will realize the futility of running down his batteries with repeated trials at the starter, breaking his back with fruitless labor at the crank, monkeying with the carburetor or indulging in any of the forms of blind and aimless tinkering to which the uninformed car owner usually resorts. Instead, he can proceed just as the capable doctor does—first to diagnose the ailment and then—and not earlier—to remedy it.

In diagnosing any trouble, the first step, of course, is to locate the seat as nearly as possible. The best way to do this is by elimination. That is, first knowing what is necessary, see what is lacking.

To illustrate—suppose the trouble is in the power plant. We know that before the engine will run there must be GASOLINE all the way from the storage tank to the carburetor where, vaporized with the right proportion of air, it becomes a CORRECT MIXTURE which is drawn into the cylinder and there subject to COMPRESSION and, while compressed, is ignited by the SPARK, causing an explosion, which, coming at the

right time, causes the moving parts of the engine to rotate. These are the first essentials. How well the engine will run, if at all, and the amount of power it will produce, depends on the degree to which any of these essentials are lacking. After the engine is running, there must be ample and complete LUBRICATION of every moving part and there must be an efficient COOLING SYSTEM.

The search for the missing or partially lacking essential may begin anywhere. The car owner may guess from certain indications that the trouble is in the ignition. If so, he should play his judgment to the limit and go through his ignition system until he has found the cause of the trouble or has proven, by thorough investigation, that his ignition is all right and his guess all wrong.

Whether he starts to test out his ignition, his fuel system or his compression, he should complete one investigation before beginning another—not skip about from spark plugs to carburetor and back to cylinders, etc. In skipping about he may accidentally happen to hit on the ailing spot but, nine times out of ten, he will save time in the long run if he will fight it out like General Grant, one line at a time.

Lots of car owners have one of these mottoes hanging on their office wall that bear, in big letters, the one word THINK. However valuable that motto may be in business hours, the suggestion it conveys will be the best tool in his kit when anything goes wrong with his car. If he will just think—use his head before his hands—reason out the possible causes and then test each one out thoroughly, troubles won't trouble him much.

CHAPTER XXVIII

SOME COMMON TROUBLES—THEIR CAUSE AND REMEDY

On this and subsequent pages, a great many automobile troubles are enumerated and a remedy for each suggested. When the car owner encounters any of these particular troubles he may, on referring to the paragraph devoted to it, find a specific remedy or at least a hint that will help him find the remedy.

But no attempt is made to undertake the manifestly impossible task of enumerating and prescribing for each of the possible instances or variaties of automobile troubles and while the car owner may find these trouble hints helpful, he should understand that they can not, entirely make up for a lack of knowledge of his car or remedy his inability to reason out for himself his troubles as they occur.

Starting Motor Fails to Rotate:

(A) Test condition of battery by turning on lights. If lights dim when starter button is pressed and brighten when released, battery is too weak.

(B) Examine battery and starting switch terminals for looseness and corrosion. All connections should be clean, bright and tight.

(C) Examine wiring for broken insulation; observing also for insulation which may have become useless through being oil soaked.

(D) Examine self-starter switch spring for weakness due to lost temper.

(E) See if commutator is clean; if not, put a little oil on bit of cloth and hold it on the surface while commutator is running, being sure to wipe off all oil. If this does not remove dirt, use strip of No. 60 sandpaper and hold it against com-

mutator while it is running. Never use emery or crocus cloth for this purpose. Be sure to blow out all sand and dust afterwards.

(F) See if commutator brushes are dirty or worn, if they fit in their holders, that the spring tension is tight enough.

Do not disturb commutator or brushes until all other causes have been tested out.

Starter Turns Engine Over Very Slowly:

(A) If starter stops after turning engine ovew two or three times the cause is most likely due to weak battery.

(B) Brush contact may be poor. (See "E" in preceding paragraph.)

(C) Engine may be stiff due to cold or poorly lubricated bearings.

Engine Fails to Start: If the starter turns the engine over but the engine fails to fire, release the starter button at once so as not to run down battery and seek the trouble elsewhere.

(A) See first that the ignition has been turned on and that the mixture has been temporarily enriched by decreasing air (choking) or by increasing gasoline (priming).

(B) Investigate gasoline supply at carburetor. If dripping or leakage is observed, the carburetor is flooding. If no leakage is observed, open pet cock under carburetor to permit escape of water which may be obstructing gasoline flow also to observe if gasoline is reaching carburetor. If there is no drainage or if drainage soon stops, see if there is gasoline in storage tank, that the air vent in storage tank is open and that the shut-off in gas line is open. See if water or sediment is obstructing gasoline flow by opening drain plug at bottom of storage tank, thus permitting any accumulation to escape. If gasoline still fails to reach carburetor and gravity system is used, investigate for obstruction in feed pipe or floating obstruction in tank. Such an obstruction may also be the cause of the trouble if vacuum system is used and gasoline fails to reach vacuum tank. If gasoline reaches tank but still fails to reach carburetor, clean screen at fuel entrance to vacuum tank. Open drain plug at bottom of vacuum tank to permit escape of possible water accumulation. If tank seems to be empty refill by closing throttle and turning engine over a few times with spark off. Finally, clean carburetor strainer.

(C) Due to excessive priming or carburetor flooding, cylinders may be filled with raw gasoline. Open relief cocks, cut off throttle and turn over engine until explosion occurs indicating that excess has been eliminated, then close relief cocks and turn engine over with throttle almost closed.

(D) Disconnect spark plug wires and holding them about three-eighths of an inch from the plug terminal, see if good

spark jumps the gap when engine is cranked. No spark probably indicates broken connection or faulty insulation causing short circuit—no spark may also indicate broken spark plug porcelain.

(E) Check wiring for loose connections, corroded terminals and broken insulation.

(F) See that timer or distributor is clean and free from moisture.

(G) If vibrator coil is used for each cylinder, lack of spark at plug may be due to vibrator points having become burned, pitted or out of line, making good contact impossible. The remedy is to smooth these points with thin flat file so that all surfaces meet each other squarely.

Engine Starts and Runs, but Misses Irregularly at Low Speeds: If this occurs in cold weather, the trouble will probably cease after engine warms up. If it does not, then:

(A) See if missing is confined to a certain cylinder or cylinders. If the missing cylinders can be determined, the search for the trouble can be confined to these. In any event, switch from the battery system to magneto system and vice versa to see which system is at fault.

(B) If missing occurs on battery only, see (1) that the switch connection is tight, (2) that the battery terminals and connections are clean and tight, (3) that the wires are unbroken and that there is no broken or chafed insulation.

(C) If missing occurs on magneto only, see (1) that the switch connections are tight, (2) that the magneto wiring is not broken, chafed or grounded, (3) if wiring and connections are O. K. and the trouble still continues and can not be located elsewhere, have the magneto examined at the service station maintained for magnetos of that make.

(D) If missing occurs on both battery and magneto and the connections and wiring are known to be o. k., see (1) if any of the spark plugs are dirty or have cracked porcelains. This will be simplified if the missing cylinder or cylinders can be located. (2) See that spark plug gaps have proper opening—1-32 of an inch for coil ignition, 1-64 of an inch for magneto ignition. (3) If car has vibrator coil, the vibrator points may have become dirty or may be out of adjustment. Clean with fine thin file and tighten retaining screw until the distance between the stationary and movable points is not more than 1-32 of an inch. (4) See that the timer is clean and free from moisture. (5) Timing may be wrong; in which event refer to instruction book for car for proper timing or, better, take car to service station.

(E) If trouble is not located in the timer or any part of the

electric system, it may be due to (1) poor compression, (2) leak in inlet pipe, valve or connections which can be discovered by squirting gasoline at each point in turn and observing if engine picks up; (3) inlet valve may be sticking; (4) exhaust valve spring may be so weak as to permit valve to open on suction stroke, thus drawing burned gases back into cylinder; (5) gasoline line may be partially clogged. (6) carburetor nozzle may be partially clogged; (7) water may have accumulated in the carburetor. (8) Some carburetor adjustment may be needed.

If Lights Dim When Starter Is Used:

(A) Almost always indicates weak battery.
(B) May indicate loose battery terminal or loose ground connection.

Lights Brighten When Speed Increases—Dim When When Speed decreases:

Another indication of weak battery.

If Bulbs in One Socket Burn Out in Quick Succession:

(A) Probably due to short circuit.
(B) Lamps may not be of proper voltage.

Fuses Blow Out Frequently:

(A) Fuse capacity may be too low.
(B) Likely a short circuit somewhere.
(C) Lamps may not be of right voltage.

Radiator Consistently Over-Heats:

See under head of "Engine Over Heats," this chapter.

Radiator Leaks:

See page 112.

Radiator Freezes:

(A) Do not attempt to thaw by running engine. Melt ice by pouring warm water on radiator. Don't try to melt too quickly. Be sure passages are all free from ice before starting again. Then drain out water and refill with anti-freeze solution. See also page 113.

Fan Troubles: Nearly always caused by lack of lubrication, worn fan bushings, failure to adjust as provided so as to give fan belt proper tautness. Knocks, sometimes sought for elsewhere, are caused by fan

belt striking pulley or fan blades striking radiator. Keep fan belt from getting greasy, clean occasionally, keep fan belt tight by adjustments provided for that purpose.

Gasoline Does Not Reach Carburetor:

See paragraph B under heading "Engine Fails to Start," this chapter. Also pages 101, 102, 103.

Carburetor Overflows or Floods: Apparent overflow may really be caused by a leak at one of the connections. Look for such before touching the carburetor. If due to some carburetor condition, it may be caused by:

(A) A small particle of dirt having lodged under the float valve. Remove small cap on top of the float chamber and lift or turn needle valve stem and the dirt will probably be released.

Engine Back Fires Through Carburetor: (Not to be confused with the less important "snapping," "popping" or 'sneezing" in carburetor.)

(A) Intake valve bushing may be so worn as to require replacement.

(B) Valve seat may have become foul or pitted so that it may be necessary to re-seat it.

(C) Intake valve spring may be so weak as to require replacement.

(D) An air leak in the inlet manifold connections may also be cause.

(E) Intake valve may not be properly timed and opens before burning charge has been exhausted.

(F) Mixture may be weak or fuel may be slower burning than carburetor is adjusted to take.

(G) Might be due to water in carburetor.

(H) Another possible cause is partial obstruction in gas line.

Engine and Car Stop Gradually: Usually accompanied by back firing and almost invariably caused by lack of gasoline or stoppage of flow. If there is plenty of gas in storage tank, check for obstructions all the

way from the air vent in the storage tank to the carburetor nozzle:

(A) Needle valve of carburetor may have jarred shut.
(B) Might be due to exhausted batteries—if running on batteries.
(C) Spark plugs may be badly fouled through excess lubrication.

Engine and Car Stop Suddenly: Due to some mechanical trouble; there may be a frozen bearing, broken connecting rod or other condition which has suddenly exerted a braking action of the car.

Engine Stops Suddenly—Car Gradually: Almost invariably caused by some interference with the ignition. Look for broken or disconnected wires, loose switch connection or anything that might stop current. If stream has recently been forded, look for water in timer or distributor.

Engine Will Not Stop:

(A) If engine is running smoothly, the cable between the magneto and switch has become disconnected.
(B) If firing is irregular, the trouble is probably caused by over-heating due to carbon accumulation in cylinders having become incandescent, thus continuing to explode charge after ignition is cut off.
(C) Stop engine by cutting off gasoline supply so that trouble can be investigated.

Engine Knocks: No engine knock is a boost. Its cause should be investigated as soon as it develops. It is an unmistakable evidence of trouble and while the trouble may be of a minor nature and easily remedied, it may, on the other hand, indicate a condition calling for an important repair which, if neglected, may result in very serious trouble.

(A) Engine may be over-heated due to one or more of the causes mentioned in preceding section, this chapter "Engine Over Heats."
(B) Bearings may have become excessively hot through lack of lubrication.
(C) Let engine cool, lubricate bearings thoroughly and start

up very cautiously and observe for any indication of tightness.

(D) See if oil holes have been clogged up.

(E) If engine is not excessively hot, the trouble may be due to driving with spark too far advanced.

(F) If sound is apparently coming from one or more cylinders, and if it has a metallic sound and occurs regularly with each explosion and increases in violence as throttle is open, it is almost surely caused by carbon accumulation in cylinder or on piston heads. Such accumulation can probably be removed as suggested on page 78.

(G) Should the knock be slight on the level but increase on hills, the trouble is probably due to worn piston rings or pistons. This can be definitely established by taking out spark plugs and pouring about a quarter of a tea cup full of heavy oil into each cylinder or into the cylinder from which the knock apparently comes. Crank engine slowly by hand until oil works around rings. Replace spark plugs and start engine. If knock is no longer apparent, the heavy oil has "cushioned" the piston from the cylinder, thus stopping the trouble. This is only temporary and is a test rather than a remedy. As soon as the oil gets hot, it will thin and the trouble will start again. Have mechanic make permanent repair as nature of trouble requires.

(H) A "muffled" knock may be due to loose connecting rod or loose piston rings.

(I) A heavy pounding knock, occurring regularly, may come from the crank shaft main bearing.

(J) A "grinding" knock may be caused by imperfect meshing of cam shaft gears.

(K) Frequently located in valves due to gummed valve stems, worn valve stems or improper push rod adjustment. Have car examined at service station.

(L) Has been known to be caused by cylinder being loose on base.

(M) Can be caused by over-rich mixture which, however, can be tested by observing color of explosive flame or color of exhaust smoke—see page .....

If an engine develops a knock, which can not be definitely traced to ignition, carbon, loose or worn pistons or to carburetion, put the car in the hands of a competent repair man without delay.

Engine Vibrates:

(A) Engine loose on frame. Tighten all retaining bolts.
(B) Uneven compression in more than one cylinder.
(C) Pistons of different weight may also cause vibration.
(D) One or more pistons may be sticking.
(E) Crank shaft might be sprung.

The first mentioned possible cause ("A") of course increases vibration which may be due to any of the other possible causes.

Engine "Hisses" or "Wheezes:"

(A) Probably a compression leak. See if compression cock is partially open. May be compression leakage around spark plug or valve caps may be loose. Joint between engine and exhaust pipe may be leaking. Exhaust pipe may be cracked.

(B) Might be due to broken spark plug porcelain.

Engine Starts and Runs, but Misses at High Speed Only:

(A) Switch from magneto to battery or vice versa to determine which system, if either, is at fault and proceed to investigate possible causes as described in paragraphs A, B, C, D and E in preceding section.

(B) Breaker arm may be sticking. Clean pivot bearing.

(C) Breaker contact opening may be too small, if misses are worse with spark advanced. Remedy by gradually screwing in breaker contact screw, stopping as soon as engine begins to run smoothly—being sure of ability to return screw to original position should this adjustment fail to stop trouble.

(D) If new car, carburetor may not have been set for high speed. If the car is old and it has been running satisfactorily, the trouble is not likely to be found in the carburetor.

Engine Starts, but Will Not Pull: If this occurs in cold weather, it may be due to engine not having had time to warm up.

(A) If accompanied by missing, the battery may be too weak.

(B) If accompanied by "popping" in carburetor, the mixture may be too lean due possibly to water in gasoline or partial obstruction of gasoline flow.

(C) If accompanied by black smoke from muffler, the carburetor mixture may be too rich, due possibly to derangement of carburetor float.

(D) There may be leakage around intake valves or connections. Test by squirting gasoline on each in turn and observe if engine seems to pick up.

(E) Compression may be poor. (See index).

Engine Over Heats:

(A) First investigate cooling system. Water may be too low in radiator. Fan belt may be off or slipping, due to dirt or grease. Circulation of water may be impaired by clogging

of water passages. Flush and clean as directed in Chapter on The Cooling System, Its Care—see index. Water passages may be closed by radiator having been "dented in." Inner lining of hose connection may have become looose and is obstructing water flow. Exterior of radiator may be covered with mud, preventing heat radiation. If forced circulation, water pump may need repacking.

(B) Look to the lubrication. The oil supply may be too low or the oil being used may not be of the correct type. The oil may have become too thin through long use—in which case, it should be drained, the crank case cleaned and fresh oil put in. If forced lubrication, the strainer of the oil pump may be clogged or, if weather is cold, the oil may have become so congealed that pump can not draw it from the pan. The oil pump may not be functioning—distributor pipes may be clogged —pump may need priming.

(C) Overheating will always result from running too long with spark greatly retarded.

(D) May be due to carbon deposits on cylinder or pistons. (See index, The Care of the Engine, for suggestions on carbon removal.)

(E) May be caused from driving too long in low gear or to combination of driving with throttle too wide open and spark too far retarded.

(F) Carburetor mixture may be too rich as will be indicated if exhaust smoke is in large volume and very black.

Engine Back Fires in Muffler: Anything that will cause a cylinder to miss will also cause back-firing in muffler. May also be caused by exhaust valve leaks.

Engine Lacks Power:

(A) Most frequently caused by poor compression due to compression leaks, carbonized, scored or cracked cylinder or pistons or to worn or otherwise defective piston rings. (See pages 75, 79, 118.)

(B) May also be caused by improper valve timing or incorrect spark timing. Have this tested by service station maintained for yoiur make of car.

(C) May possibly be remedied by running with spark further advanced.

(D) Always results from overheating. (See paragraph, Engine Over Heats, this chapter.)

(E) Another possible cause is weak spark due to condition of battery, dirty distributor or worn or loose parts.

(F) May also result, to some extent, from clogged muffler

which prevents free escape of burned gases which may cause back pressure.

(G) Dragging brakes may be compelling engine to pull against constant friction.

(H) A slipping clutch may be preventing transmission of full amount of power generated.

(I) Carburetor mixture may be too rich. Observe color of exhaust smoke.

(C) Valve may be defective in which case some repair or replacement is necessary which the car owner had better leave to the service station maintained for that make of carburetor. It may be necessary to repair or replace float. See also pages 108-109.

Vacuum Tank Overflows: If occasional, from air vent, no attention should be paid to it. If continuous:

(A) See if air hole in storage tank is clogged and, if so, open.

(B) Cover of tank may be loose. If tightening does not remedy, new gaskets are needed.

(C) There may be a crack or break in the tubing or connections at head of tank.

(D) Connection to carburetor may be loose.

See also page 107.

Carburetor Freezes: Due to presence of water in the gasoline. Can be prevented by straining gasoline into storage tank through chamois. If this is not done, the carburetor should be frequently drained during cold weather. If the carburetor should freeze, the condition will be readily observed by stoppage of gas flow. Thaw by pouring on warm water or by wrapping in heavy clothes wrung out of very hot water.

Carburetor "Pops" or "Snaps:" Probably due to cold engine and will stop when engine is warmed up. Otherwise, may be due to weak mixture which in turn may be caused by water in the gasoline, partially clogged fuel line, strainer may be clogged, a particle of dirt may have lodged under needle valve.

Carburetor "Hisses" or "Wheezes:"

(A) Choke may be pulled out too far.
(B) Butterfly may be loose on the air valve pilot.
(C) Choke valve wire may be too short.

Magneto Noises:

(A) A knock is likely due to loose magneto coupling.
(B) A "click" or "rumble" is nearly always caused by lack or neglect of lubrication.

Observe manufacturers instructions religiously as to places to lubricate and character of lubricant to use. Leave magneto adjustments and repairs to a competent service station.

Generator Fails to Charge Properly:

(A) Cable might be disconnected.
(B) There might be a short circuit in cut out switch.
(D) Brush adjustment may not be correct.
(E) Brushes may be worn.
(F) Carbon dust may be causing a ground.
(G) Commutator may be dirty.

The car owner would do well to find out the proper charging rate of his generator and to observe, every now and then, if the generator is functioning properly but repairs or adjustments should be made ONLY by the service station maintained by the manufacturer.

Excessive and Continuous Smoke from Muffler: Any noticeable amount of smoke coming regularly from the muffler is "excessive" and not only creates a nuisance which some cities punish by a fine, but also indicates expensive waste of lubricating oil or gasoline:

(A) When muffler smoke is blue or bluish-white, it indicates that too much lubricating oil is being used—either because the crank case is too full or because the piston rings are leaking.
(B) Blue or bluish-white smoke coming in intermittent puffs, indicates over lubrication or leaky piston rings in one or more cylinders only.
(C) When muffler smoke is black, it indicates use of too much gasoline—an over-rich mixture which reveals the need, usually of some carburetor adjustment.

Need of Carburetor Adjustment Indicated by Color of Explosive Flame: A blue flame observed at the open priming cock indicates a correct mixture; a white flame a poor or too-lean mixture; a red flame indicates an over-rich mixture.

Oil Leakage: The few spoons full of oil observed on the street or on the garage floor after the car has

been standing a while, may seem too small to be concerned about but the amount lost in a year may have a value that should encourage the car owner to stop the leak.

These drips may come from:

(A) Loose cap screws on crank case.
(B) Loose bolts or defective gaskets on transmission gear case or differential.
(C) May be due to absence of felt retaining washers usually provided.

Water in Crank Case: One of the products of combustion is water which should pass out with exhaust in the form of vapor. Its preseence in the crank case very likely indicates a tendency to "oval" in the cylinder caused by the thrust of the connecting rod being against one side on the up-stroke and against the other on the down stroke.

Flooded Cylinder: Usually due to engine having been cranked repeatedly without firing and the cylinders, in consequence, flooded with almost pure gasoline which has condensed in the cold cylinder and which, naturally, will not explode. Open priming cock and crank engine until the over-rich mixture has been expelled or diluted. Then close cock and engine should fire.

Frequent or Excessive Fouling of Spark Plugs:

(A) May be due to loose or otherwise leaky piston ring.
(B) If soot is soft and very black, the cause is probably an over-rich mixture.
(C) If the plugs are oily and sooty at the end, there is probably a leaky exhaust valve.

Stuck or "Seized" Pistons: Nearly always due to lack of lubrication. Open relief cocks or take out spark plugs to relieve compression and pour in kerosene

liberally. Then endeavor to turn engine over by hand or the starter or both. If unable to move piston, let stand awhile to allow kerosene longer time to penetrate or try pushing or towing, starting with the gear in high and clutch out. After car has attained some momentum, engage clutch cautiously so as not to run any risk of stripping gears or even of breaking drive shaft. After succeeding in moving piston, open drain cock to permit escape of kerosene and old oil and refill crank case with new oil. Thereafter, the engine should be run very slowly in order to permit the new oil to work to all parts of cylinder.

If None of Light Bulbs Light:

(A) Bulbs may be burned out or filaments broken.
(B) Look for broken connections, broken wires and broken insulation.
(C) If grounded system, examine ground connections.
(D) Fuse may be blown.
(E) Battery may be discharged.

If Lamps Flicker:

(A) May be due to loose connection.
(B) May be small break in insulation causing intermittent short circuit.
(C) Ground contact may be loose. See if both lights or only one is affected. If only one seek the trouble on that circuit only.

If Any One Bulb Fails to Light:

(A) May be burned out or filament broken.
(B) Perhaps no contact at socket; screw up tighter.
(C) If another bulb will burn in same socket, the trouble must be in the bulb.
(D) If another bulb will not burn in that socket, examine that circuit for bad connections, broken wire, broken insulation and defective grounding—perhaps in headlight rim.

If Lights Are Dim:

(A) Probably due to weak battery.
(B) Battery connections probably loose or corroded.
(C) Lamps may be old and carbonized. Replace with new.
(D) Ground connections, usually in headlight rim, may be loose. Press firmly into place.

Ammeter Inconsistencies: If the ammeter registers

"charge" or "discharge" when the car is standing still with the lights off; if it registers neither one when the car is running or if it indicates "charge" at low speeds or "discharge" at high speed—it is a sign of trouble that may range anywhere from a bent ammeter needle or reversed ammeter wires to a short circuit or bad connections. In any event, the trouble is one that nearly always calls for a visit to the service station and there's little luck in postponing the trip there.

Battery Heats: Most likely due to over-charging. Burn lights more frequently or run down with starter.

(A) Generator may not be functioning properly.

Battery Discharges Too Quickly:

(B) Possibly due to loose connections.

(C) Wiring may be grounded somewhere between battery, generator and switch.

(D) There may be an internal short circuit.

(E) Perhaps car is used too little or run at speed too low to keep battery charged.

(F) Might be due to one or more leaky cells.

(G) If frequent stops are made and starter used each time to start again, this may be running down battery.

All this, assuming that the car owner is making it a point to see that his batteries are inspected at least twice a month and that water is being added as needed. See page 96.

Brakes Do Not "Take Hold" Properly:

(A) Drum or band facings may have become oily or dirty. Wash with gasoline and apply few drops of neats foot oil.

(B) Lining may have worn "slick." Roughen with rasp and apply few drops neats foot oil.

(C) Linings may be worn out; replace.

(D) Bands may be too loose; adjust as provided.

See also page 126.

Brakes "Grab:"

Bands too tight—not enough clearance. Adjust as provided.

Brakes Drag: Usually confided to one wheel. Test by

jacking up rear wheels, starting car and applying brakes in usual way, observing action on each wheel. Braking action should be the same on each. If action on one is more "severe," adjust as provided until action is equal.

(A) See, also, that springs completely disengage brakes when released.

Brakes "Shriek:"

(A) Nearly always the case when making a "wild west" stop—a too sudden application of brakes.
(B) Caused also by dirty linings. Clean with stiff brush dipped in gasoline and appply few drops of neats foot oil.

Brakes Rattle or Clatter:

(A) Frequently caused by brake rods striking together. Wind rods separately with tire tape to make buffer at contact point.
(B) Clevis yoke may be spread. Drive together.
(C) Clevis pin may be worn and should be replaced.
(D) Lock nut at clevis may be loose.
(E) Connections may need lubrication.
(F) May be caused by loose bearing at emergency brake lever joint, due possibly to worn bushing.
(G) Plunger spring may be loose.

Clutch "Slips:"

If cone clutch:
(A) May be due to surface being covered with oil or grease. Clean by squirting on gasoline. (Temporary and not advised—throw in fullers earth or sand.)
(B) May be glazed from wear due to driver keeping foot constantly on clutch pedal. Fasten pedal in "out" position, put on little neats foot oil and roughen with small saw or other abrasive tool.
(C) Clutch leather may be worn out; replace.
If metal-to-metal type.
(D) Clutch spring may be too weak.
In either type, see if clutch pedal moves freely and to the full extent of the "in" and "out" positions. See page 122.

Clutch Grabs. If cone type:

(A) Clutch leathers may be hard or dry. Soften with dressing of a few drops of neats foot oil.
(B) Springs may be too tight.
If disc type:
(C) Plates may need cleaning.
(D) Lighter oil may be required.
(E) Spring may be too tight.

Difficult Gear Change:

(A) Shifting members may be stuck on shaft.

(B) Gear teeth may be burred or broken.

Care in gear changing and religious observance of necessary lubrication should prevent trouble in gears.

Gear Shift Lever Rattles:

(A) May be worn ball socket. Lubrication with heavy grease will temporarily remedy.

(B) Ball may be worn. Dent in socket slightly.

(C) Bearing may ge worn. Put in thin washer at joint.

Abnormal Noise In Transmission: Should have immediate attention.

(A) May be due to lack of lubrication of change gears or bevel gear on rear axle.

(B) Sliding member of clutch may be out of alignment.

(C) Worn bearing, gears or teeth.

(D) Loose nut or other piece of metal in gear case. Very dangerous to run until it is removed.

Abnominal Noise in Differential:

(A) Slight grinding indicates neglect of lubrication.

(B) A click, likely indicates a chipped gear.

(C) A grinding knock probably means a broken tooth catching in gears.

(D) An uneven growl is likely to mean that the ring gear is meshing too loosely.

Abnormal Noise In Universal Joint:

(A) Sleeve connections may be loose. Tighten flange bolts.

(B) May also be caused by neglect of lubrication.

(C) A "slap" may mean that the bushings are worn. Turn them end for end.

Excessive Play in Steering Wheel:

(A) May be caused by loose drag links. Adjust as provided.

(B) Gear tooth may be worn. Take up on eccentric bushing.

(C) Possibly due to loose or worn out bearings. Replace or tighten as provided.

Squeaks and Rattles: Most frequently caused by looseness or lack of lubrication. Some of the most common sources are:

(A) Look at the springs. Tighten the bolts and lubricate between leaves and at ends.

(B) Perhaps lubrication of clutch forks has been overlooked.

(C) Maybe the valve stems are dry.

(D) The radiator may be loose.

(E) The fuel tank may be loose.

(F) Perhaps the upper steering shaft bearing is dry.

(G) The torque rod connections may be loose.

(H) The body retaining bolts may need tightening.

(I) Door hinges may be loose or dry. Graphite grease is a fine lubricant for them.

(K) Fender bolts may need tightening. Try a felt or leather washer.

(L) If hood buffers are worn out, replace with strips of felt or leather.

(M) Rattling doors can be quieted with little buffers of "cure cut" or "tire putty."

(N) Wind shield squeeks can be relieved by applying graphite grease at support bearings.

(O) Keep rim lugs tight.

(P) Keep lamp brackets tight.

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